



# MOST IMPORTANT DEVELOPMENTS OF THE NATIONAL ACADEMY OF SCIENCES OF BELARUS



NATIONAL ACADEMY OF SCIENCES OF BELARUS



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E d i t o r - i n - C h i e f

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The developments included in the catalog are characterized by technical and technological novelty, competitiveness, export- and import-substituting potential, objectively reflecting the importance of scientific, technical, and innovative activities of scientific teams of organizations of the National Academy of Sciences of Belarus in the industries, agriculture, and society ensuring the accelerated development of the economy of our country.

Intended for employees of state authorities, managers and specialists of organizations of the Republic of Belarus.

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Currently, the National Academy of Sciences of Belarus functions as a scientific and production corporation, combining both science and production, and is aimed at solving the most important socio-economic problems of the country with the phased implementation of the Megaproject to create the Belarus Intellectual model (full-format introduction of digital technologies as the basis for building an IT country, new industrialization in all areas, and the Society of Intelligence).

Academic scientists see the target mission of the future Belarus to become a leader in key vectors of scientific and technological development on the basis of a predominantly intellectual factor.

The Academy of Sciences has widely deployed the work in the interests of all sectors of the economy. We are conducting our work in two directions. The first one is scientific support for the modernization of economy sectors, and the second direction is the organization of its own production of innovative products, materials, devices for the needs of the republic and for export. Analyzing the dynamics of qualitative indicators of scientific and innovative activities of the National Academy of Sciences of Belarus, we can talk about the steady progress in both directions.

The country is implementing a targeted method for carrying out scientific, technical, and innovation activities within the framework of priority areas and state programs of scientific research and scientific-technical programs approved for 2021–2025, including scientific support of these state programs.

So, within the framework of state, sectoral, and regional scientific and technical programs and activities in 2022–2023, 392 innovations were developed and brought to the stage of practical application, including 35 equipment types (machines, devices), 27 new materials and substances, 48 technologies, 282 types of medicines, methods, and other scientific and technical products. 10 new production facilities were established and 27 existing ones were modernized, technical training of 46 production facilities was carried out.

The active cooperation of the National Academy of Sciences of Belarus with sectoral ministries and organizations of the real sector ensures the prompt creation and introduction of innovative products.

*Academician V. G. Gusakov,  
Chairman of the Presidium of the NAS of Belarus*





DEPARTMENT  
OF PHYSICS, MATHEMATICS,  
AND INFORMATICS

State Scientific and Production Association  
“Optics, Optoelectronics, and Laser Technology”

## HARDWARE AND SOFTWARE COMPLEX OF LASER-OPTICAL SCANNING FOR AUTOMATED BALLISTIC IDENTIFICATION SYSTEM



### Development Description

The complex provides the possibility of obtaining two-dimensional and three-dimensional high-resolution images of ballistic identification objects (bullets and cartridges with traces of a shot from a rifled firearm) and carrying out the process of ballistic identification by comparing newly obtained images with reference to ones located in the ballistic identification database using the developed software.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The optical resolution of two-dimensional and three-dimensional images of 1.5 microns; the ability to obtain images of the side surface of bullets with a caliber from 4.3 to 12.7 mm and a bullet height from 6 to 70 mm; the ability to obtain images of the bottom surface of cartridge cases with a diameter from 5 to 30 mm, for cartridge cases with a height from 6 to 114 mm; the type of scanner is laser-optical linear polychromatic confocal, the layout of

the device is combined for bullets and cartridge cases. The complex has no analogues in the Republic of Belarus and the CIS countries and is at the level of the best world analogues.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Standards and Scientific Devices”, 2016–2020; subprogramme “Unique Scientific Equipment”; Task 1.11 “Develop and manufacture the hardware and software complex of laser-optical scanning for automated ballistic identification system”;

State Scientific-Technical Program “National Standards and High-Tech Research Equipment”, 2021–2025; subprogramme “Equipment for Advanced Scientific Research”.

#### Field of Application

The formation of optical images, optical devices and optical measurement methods, forensic examination.

#### Contact Information of Organization-Developer

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State Scientific and Production Association  
“Optics, Optoelectronics, and Laser Technology”

## OPTOELECTRONIC OSCILLATOR



### Development Description

The optoelectronic oscillator is a source of microwave signals with a high spectral frequency in modular design, which allows it to be used as part of frequency synthesis systems of modern and promising microwave radar systems and microwave measuring equipment.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The optoelectronic oscillator has the magnitude phase noise (less than  $-140$  dBc/Hz at a 10 kHz offset frequency from a 10 GHz microwave carrier) lower than electronic microwave oscillators with frequency conversion ( $-125$  dBc/Hz at a 10 kHz offset frequency from a 10 GHz microwave carrier). It has no analogues in the CIS countries and is at the level of the best world analogues.

### Intellectual Property Protection

None.



**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Program of the Union State “Development of critical standard technologies for the design and manufacture of nanostructured micro and optoelectronics products, devices and systems based on them and equipment for their production and testing” (“Luch” 2016–2019).

**Field of Application**

Radar systems, microwave measuring equipment.

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## AIR PLASMA JET GENERATOR



### Development Description

The instrument generates an air plasma jet containing nitrogen reactive particles and having a bactericidal effect on cells of various organization levels, as well as healing effect at treating infected wounds.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Compactness of the instrument due to the environmental air application. Inert gases are not needed. Effectiveness at microorganisms inactivation and wound healing. The air plasma jet generator meets the world level by its characteristics. There are no domestic analogues.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Convergence-2020”, 2016–2020; subprogram “Micro-world, plasma and Universe”; task 2.4.01 “Non-equilibrium and collective processes in application to innovation plasma technologies”.

### Field of Application

Healthcare, veterinary, cosmetology. The instrument can be used for the effective sterilization and sanitation of surfaces, including heat-sensitive

ones, such as living tissues. The instrument can also be a prototype for the development of other physiotherapeutic instruments.

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## LASER THERAPEUTIC APPARATUS "PROMETHEY"



### Development Description

The apparatus is designed to treat a wide range of diseases of various origins and provides implementation of all phototherapy technologies currently used in laser therapy: treatment of the external and intra-cavity pathological loci, transcutaneous laser and magnetic laser treatment of blood, intravenous (intravascular) laser treatment of blood (ILBI therapy) using sterile disposable light guides, treatment of biologically active points and zones (Zakharyin-Ged tender zones).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

By the effectiveness of treatment of various diseases, functional characteristics and technical parameters of the laser therapeutic apparatus "Promethey" corresponds to the best foreign analogues or surpasses them. The instrument is designed on a modern element basis of semiconductor lasers with various spectral ranges. The therapeutic apparatus is highly efficient due to:

- choosing the optimal laser radiation wavelength depending on the nosology and localization of the pathological locus;
- combined laser therapy with radiation of different spectral range;
- combined magnetic laser therapy with maximum magnetic field strength in the area of laser radiation; optical radiation modulation;

- bactericidal effect of radiation from blue spectrum region corresponding to the absorption band of endogenous photo-sensitizers localized in microbial cells.

The apparatus provides:

- use of light guide heads with different direction diagram of optical radiation and availability of hollow organs;
- automatic control of operating radiation parameters during the laser therapy procedure;
- regulation of the exposed radiation power, including the power of pulsed radiation;
- measurement and automatic calibration of laser radiation power according to the sensor integrated in the instrument.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

The development is based on the investigations conducted within State Research Program “Photonics and electronics for innovations”, 2021–2025; subprogram “Photonics and its applications”, task 1.6.1 “Development of laser-optical methods and theranostics devices using laser and LED sources for application in medicine, biotechnologies and agriculture”, No. SR 20210446 dated 31.03.2021.

#### Field of Application

Low-intensity laser (magneto-laser) therapy of a wide range of diseases of various origins based on noninvasive and invasive treatment with laser radiation. The apparatus is designed for the use in healthcare institutions.

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## PHOTOTHERAPY APPARATUS FOR TREATMENT OF HYPERBILIRUBINEMIA OF NEWBORNS



### Development Description

The apparatus is intended for the treatment of physiological (non-infectious) hyperbilirubinemia of newborns by exposure of the blue-green spectrum region light to the surface of the child's body. The therapeutic effect is achieved by photo-conversion of bilirubin into photoisomers, the excretion speed of which is higher than that of bilirubin.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

By the effectiveness of treatment of hyperbilirubinemia and technical characteristics the phototherapy apparatus corresponds to the best foreign analogues or surpasses them. The instrument is designed on the basis of a modern LED element base of various spectral ranges providing high phototherapy effectiveness with a certain combination of blue and green com-

ponents. The increased effectiveness of phototherapy of newborns with hyperbilirubinemia is achieved by:

- selection of the spectral range in which the screening effect of hemoglobin is lower, but quantum yield of lumirubin (the structural isomer of bilirubin specifying the photo-therapy effectiveness) is maximal;
- higher radiation power density on the surface baby's body, providing the effective reduction of bilirubin level with no side and harmful effects;
- opportunity of adjustment of the affected radiation intensity depending on the disease severity;
- uniform distribution of radiation power density over the surface of the child's body.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

The development is based on the investigations conducted within State Research Program "Photonics, opto-, and microelectronics" (subprogram "Photonics"), 2016–2020. State Research Program "Photonics, opto-, and microelectronics", task 1.3.01 "Development of optical technologies and devices providing the increase of biological activity of laser and led sources for their effective application in medicine and agriculture in combination with other physical factors" (No. SR 20160094 dated 15.02.2016).

Field of Application

Treatment of newborn children with hyperbilirubinemia syndrome using closed or open incubators for nursing newborns.

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## NEAR-FIELD OPTICAL MICROSCOPE BASED ON EVANESCENT QUASINONDIFFRACTION LIGHT BEAMS



### Development Description

The near-field scanning optical microscope (Near-field microscope) is based on the use of evanescent Bessel light beams. The novelty of the method is in the use of a Bessel light probe to detect defects in the regime of frustrated total internal reflection at the boundary of the object under investigation. The Bessel light probe allows illuminating defects simultaneously from all azimuths, increasing the sensitivity to their detection. The property of self-recovery of a Bessel structure of the probe after its destruction by a defect makes it possible to detect several defects located at different depths.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

By scientific and technical level relative to the best domestic samples the Near-field microscope set has no domestic analogues and analogues in the CIS countries. As for the world best samples, by a number of technical solutions, including a light evanescent probe based on zero- and second-order Bessel beams, differential signal processing algorithm, crystalline Bessel beam order converter, as well as the prospects of functioning of the light probe in resonance mode with surface plasmons and polaritons, this development meets the world level. According to a number of features, the created Near-field microscope set can be attributed to the fifth techno-

logical order. The light probe of the microscope is evanescent and replaced by Bessel probe instead of a Gaussian one. This makes it possible to illuminate defects simultaneously from all azimuths increasing the sensitivity to detection of weak defects. For the first time, a difference algorithm for information signal processing is proposed, which is based on the use of two light probes with a structure of zero- and second-order Bessel functions. This allowed receiving a spatial resolution of less than  $1/3$  of the wavelength when using probes of relatively large diameter. The technical implementation of the difference algorithm is achieved by using a converter of an order of Bessel functions on the basis of uniaxial crystal and using a balanced optical detector. The use of the immersion layer between the lens probe and the object makes it possible to substantially increase the gap thickness between them and to reduce the requirements for maintaining this thickness during the object scanning.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Etalons and scientific devices”, 2016–2020; subprogramme “Unique scientific equipment”; task 1.1 “Development and manufacture of near-field optical microscope on the basis of evanescent quasinondiffraction light beams” (“Near-field microscope”), 01.07.2016 – 31.12.2020.

#### Field of Application

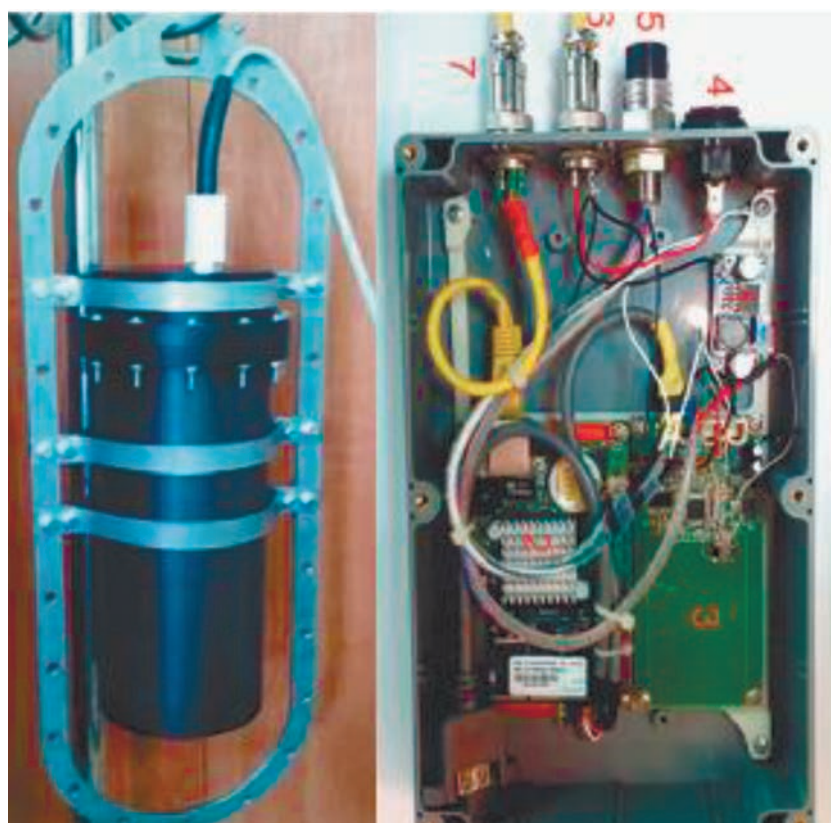
The application areas of the device are optics, optoelectronics, laser technology, and microelectronics; medical diagnostics. It is used for diagnostics of various materials, as well as layered structures containing dielectric, metallic, and semiconductor layers with thickness in a nanometer range. The microscope can also be used to investigate biological objects with high longitudinal and transverse spatial resolution. Near-field microscopy is perspective for application by enterprises of optical and electronic industries of the Republic of Belarus, as well as by medical and biological institutions.

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## **AUTONOMOUS NAI(TI) GAMMA-RAY SPECTROMETER FOR IN SITU UNDERWATER MEASUREMENTS**



### **Development Description**

The automated low-background NaI(Tl) gamma-ray spectrometer for in situ underwater measurements is designed to record the level of radioactivity in the aquatic environment (seas, rivers, lakes) by radiation from radioactive elements of gamma-quanta of a frequency (energy) typical for such elements.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The main technical parameters (sensitivity and energy resolution) correspond to the best foreign analogical spectrometers with NaI (TI) detector and surpass the domestic analogues.



Technical characteristics:

- Detector type NaI (TI);
- Energy range – up to 4000 keV;
- Detection limit for  $^{137}\text{Cs}$  for 24 h  $\leq 0,035$  Bq/l;
- Energy resolution along 662 keV  $^{137}\text{Cs}$   $\sim 7$  %;
- Number of channels in spectrum (can be selected) 256, 512, 1024, 2048;
- Operating temperature  $-10\dots+50$  °C;
- Max immersion depth – up to 400 m;
- Outside pressure not more than 45 bar;
- Voltage supply from 9 to 18 V (DC);
- Power consumption  $\leq 2$  Wt;
- Communication interface RS232, USB;
- Measuring error from 8,0 up to 10,0 %;
- Dimension sizes 165 (L)  $\times$  400 (H) mm;
- Weight not more than 8 kg.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Commercial contract No.46 “Development of marine-based submersible gamma-spectrometer” dated August 30, 2013 with the Institute of Oceanographic Instrumentation of Shandong Academy of Sciences (China).

Field of Application

Measurement of the specific gamma activity of radionuclides in the aquatic environment (depth up to 400 m) during environmental monitoring, waste certification.

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## LASER-OPTICAL DEFECT ANALYZER



Development Description

The laser-optical defect analyzer is aimed to control the surface of non-structured plates made of semiconductor and dielectric materials (silicon, germanium, gallium arsenide, sapphire). The analyzer can detect local defects caused by a violation of the crystalline structure (growth defects), odd particles (dust, resist, solvents), and violation of the integrity of technological layers (scratches). The analyzer's software can make calculation of the statistics of defect distribution by size and type. The defect analyzer contains scanning module, module of display in dark and light fields, modules of imaging and registration of submicron defects, operating panel, and power supply controller.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The instrument can work with the plates of up to 200 mm in diameter and register defects with size from 0,25 up to 25  $\mu\text{m}$  on the sample surface,

corresponding to the world analogues. The minimal control time of the plate is 3 min. The important advantage of the analyzer in comparison with the analogues is the software. The software makes the statistical processing of the results with calculation of defects number and a map of surface defects localization with recognition of the defects by size and type.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of critical standard technologies for the design and manufacture of nanostructured micro and optoelectronics products, devices and systems based on them and equipment for their production and testing” (“Luch”, 2016–2019), task 5.4. “Development of the device for definition and analysis of point defects on the surface of semiconductor plates”.

#### Field of Application

The analyzer is developed for the enterprises of microelectronic and microwave industry of CIS (JSC “Integral”, JSC “Svetlana-Rost”) as an import-substituting analogue and will allow deciding actual tasks of the goods quality control at early stages of production, providing the quality improvement and reduction of the cost of the produced microelectronic and microwave goods.

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## IFL-E15-PC LASER EMITTER



### Development Description

IFL-E15-PC is a super-compact Yb-Er: glass laser passively Q-switched with Co:MgAl<sub>2</sub>O<sub>4</sub> crystal. The active element is pumped by laser diode bars on transverse mode. The laser generates unconditionally eye-safe spectral range of 1535 nm with pulse energy of 1 mJ.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

IFL-E15-PC laser emitter corresponds to the best foreign analogues by its performance characteristics (energy rate, output beam quality, operating temperature range, weight and overall dimensions, hermetic housing). The operating wavelength is within the conditionally eye-safe spectral range of 1.5–1.6  $\mu\text{m}$ .

Technical characteristics:

- Pumping type – diode;
- Q-switch – passive;
- Operation Mode – pulsed;
- Wavelength – 1535 nm;
- Pulse energy – 1 mJ;
- Pulse repetition rate – 5 Hz;
- Pulse duration – < 15 ns;

- Beam diameter –  $< 0.5$  mm;
- Beam divergence –  $< 4$  mrad;
- Beam quality factor –  $M2 < 1.5$ ;
- Cooling type – Conductive;
- Operating temperature –  $-40...+60$  °C;
- Overall dimensions –  $32 \times 25 \times 19$  mm;
- Housing – hermetic.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Photonics, opto-, and microelectronics” (sub-program “Photonics”), 2016–2020; task 1.1.4 “Development and production of powerful solid-state diode-pumped lasers with extremely narrow emission spectra, high pulse repetition rate and high output beam quality for spectroscopy, lidar technology, medical, industrial special technologies”; State Research Program “Photonics and electronics for innovations”, 2021–2025; task 1.4 “Development and research of modern laser technologies and complexes for industrial, research, and special purposes”, and commercial contracts with “Roboaeronautica” Group of Companies” LLC (Saint-Petersburg, Russian Federation) on development and production of optoelectronic devices for various purposes.

#### Field of Application

IFL-E15-PC Laser Emitter can be used as a compact narrowly focused coherent radiation source in rangefinding, spectroscopy, and medicine.

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## IFL-E25-PC LASER EMITTER



### Development Description

IFL-E25-PC is a compact Yb-Er:glass laser passively Q-switched with Co:MgAl<sub>2</sub>O<sub>4</sub> crystal. The active element is pumped by laser diode bars on transverse mode. The laser generates unconditionally eye-safe spectral range of 1535 nm with pulse energy of 2 mJ.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

IFL-E25-PC laser emitter corresponds to the best foreign analogues by its performance characteristics (energy rate, output beam quality, operating temperature range, weight and overall dimensions, hermetic housing). The operating wavelength is within the conditionally eye-safe spectral range of 1.5–1.6  $\mu\text{m}$ .

Technical characteristics:

- Q-switch: passive;
- Operation Mode: pulsed;
- Wavelength: 1535 nm;
- Pulse energy: > 2 mJ;
- Pulse repetition rate – up to 5 Hz;
- Pulse duration: < 15 ns;
- Beam diameter: < 0.5 mm;
- Beam divergence: < 4 mrad;

- Beam quality factor:  $M2 < 1.5$ ;
- Cooling type: Conductive;
- Operating temperature:  $-40...+60\text{ }^{\circ}\text{C}$ ;
- Overall dimensions:  $42 \times 25 \times 19\text{ mm}$ ;
- Housing: hermetic.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Photonics, opto-, and microelectronics”, 2016–2020; task 1.1.4 “Development and production of powerful solid-state diode-pumped lasers with extremely narrow emission spectra, high pulse repetition rate and high output beam quality for spectroscopy, lidar technology, medical, industrial special technologies”; State Research Program “Photonics and electronics for innovations”, 2021–2025; task 1.4 “Development and research of modern laser technologies and complexes for industrial, research, and special purposes”, and commercial contracts with “Roboaeronautica” Group of Companies” LLC (Saint-Petersburg, Russian Federation) on development and production of optoelectronic devices for various purposes.

#### Field of Application

IFL-E25-PC Laser Emitter can be used as a compact narrowly focused coherent radiation source in rangefinding, spectroscopy, and medicine.

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## IFL-E85-PT LASER EMITTER



### Development Description

IFL-E85-PT is an Yb-Er: glass laser passively Q-switched with Co:MgAl<sub>2</sub>O<sub>4</sub> crystal. The active element is pumped by laser diode bars on transverse mode. The laser is equipped with a telescope and generates in conditionally safe spectral range of 1535 nm with pulse energy of 8 mJ at extremely low beam divergence – less than 0.4 mrad.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

IFL-E85-PT laser emitter corresponds to the best foreign analogues by its performance characteristics (energy rate, output beam quality, operating temperature range, weight and overall dimensions, hermetic housing). The emitter is equipped with a telescope with coated optics and is characterized by extremely low divergence of the output beam. The operating wavelength is within the conditionally eye-safe spectral range of 1.5–1.6  $\mu\text{m}$ .

Technical characteristics:

- Pumping type: diode;
- Q-switch: passive;
- Operation Mode: pulsed;
- Wavelength: 1535 nm;
- Pulse energy: > 8 mJ;
- Pulse repetition rate: up to 5 Hz;
- Pulse duration: < 16 ns;
- Beam diameter: < 10 mm;

- Beam divergence:  $< 0.4$  mrad;
- Beam quality factor:  $M2 < 1.5$ ;
- Cooling type: Conductive;
- Operating temperature:  $-40...+60$  °C;
- Overall dimensions:  $155 \times 40 \times 22$  mm;
- Housing: hermetic.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Photonics, opto-, and microelectronics”, 2016–2020; task 1.1.4 “Development and production of powerful solid-state diode-pumped lasers with extremely narrow emission spectra, high pulse repetition rate and high output beam quality for spectroscopy, lidar technology, medical, industrial special technologies”; State Research Program “Photonics and electronics for innovations”, 2021–2025; task 1.4 “Development and research of modern laser technologies and complexes for industrial, research, and special purposes”, and commercial contracts with A. G. Shipunov Instrument Design Bureau JSC (Tula, Russian Federation).

#### Field of Application

IFL-E85-PT Laser Emitter can be used as a compact, narrowly focused coherent radiation source in range-finding, spectroscopy, and medicine.

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## IFL-N180A LASER EMITTER



### Development Description

IFL-N180A is a rugged Nd: YAG Q-switched laser. The active element is pumped by laser diode matrixes in transverse mode. The laser generates in near – IR spectral range on the wavelength of 1064 nm with pulse energy of more than 180 mJ.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

IFL-N180A laser emitter corresponds to the best foreign analogues by its performance characteristics (energy rate, diode pumping, output beam quality, operating temperature range, weight and overall dimensions).

Technical characteristics:

- Pumping type: diode;
- Q-switch: active;
- Operation Mode: pulsed;
- Mode structure: multimode;
- Wavelength: 1064 nm;
- Pulse energy: > 180 mJ;
- Pulse repetition rate: up to 30 Hz;
- Pulse duration: < 12 ns;
- Beam diameter: < 5 mm;
- Beam divergence: < 1.3 mrad;
- Cooling type: Conductive; air

- Operating temperature:  $-40...+60\text{ }^{\circ}\text{C}$ ;
- Overall dimensions:  $420 \times 155 \times 74\text{ mm}$ .

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

- State Research Program “Photonics, opto-, and microelectronics”, 2016–2020; task 1.1.4 “Development and production of powerful solid-state diode-pumped lasers with extremely narrow emission spectra, high pulse repetition rate and high output beam quality for spectroscopy, lidar technology, medical, industrial special technologies”;
- State Research Program “Photonics and electronics for innovations”, 2021–2025; task 1.4 “Development and research of modern laser technologies and complexes for industrial, research, and special purposes”;
- State Program “Scientific and innovation activity of the National Academy of Sciences of Belarus for 2021–2025”; subprogram “Development of the Belarusian Antarctic Station”; task “Conduct studies of spatial and temporal changes and trends in the characteristics of atmospheric aerosol, snow and ice cover, and water surface in the area of the Vechernaya Mountain station based on measurements by surface-based and satellite optical systems”.

#### Field of Application

IFL-N180A Laser Emitter can be used as a rugged, narrowly focused coherent radiation source in lidar systems, laser spectroscopy and medicine.

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State Scientific Institution “B. I. Stepanov Institute of Physics  
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## NATIONAL ETALON FOR DEVICES OF SPECTRAL BRIGHTNESS, SPECTRAL RADIANCE AND RADIATION INTENSITY IN THE WAVELENGTH RANGE FROM 0.2 TO 3.0 MICROMETRES



### Development Description

The etalon is designed to store, reproduce, and transmit the size of devices of spectral radiance, spectral brightness, and radiation intensity in the wavelength range from 0.2 to 3.0  $\mu\text{m}$  (hereinafter – reference) to operating standards and other measuring tools used for calibration, diagnostics, and measurements of optical characteristics of optical radiation sources and optical radiation receivers.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

– The design of the etalon makes it possible to measure the spectral brightness and radiation intensity at a distance between the receiver and

the radiation source of less than 200 mm, which is important for optical characteristics measurements of LEDs and some types of etalon lamps.

- The etalon allows measuring the spatial distribution of radiation intensity and spectral brightness of small-sized radiation sources, including light emitting ones.

- The etalon corresponds to the world level by its metrological characteristics. The etalon is used in key international comparisons of national etalons of the Republic of Belarus, Russian Federation, Germany, Turkey, Ukraine, and Kazakhstan in accordance with the working plan of the technical committee “PR-Photometry and radiometry” of Euro-Asian Cooperation of National Metrological Institutions (COOMET).

#### Intellectual Property Protection

The etalon was approved as the National Etalon by the Decree of the State Committee for Standardization No. 31 dated 03.06.2019 and is included in the Register of National Etalons of the Republic of Belarus as NE 51-19.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Etalons and scientific instruments”, 2016–2020; subprogram “Etalons of Belarus”; task 2.4 “Create national etalon for devices of spectral brightness, spectral radiance, and radiation intensity in the wavelength range from 0.2 to 3.0  $\mu\text{m}$ ”.

#### Field of Application

The etalon is aimed to support the metrological needs of departments and organizations that use or design space-, air- or surface-based instruments for the Earth observation, as well as for energy, agriculture, medicine, and pharmacy, bio- and nano-industry, rational use of natural resources.

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## NATIONAL ETALON FOR POLARIZATION MODE DISPERSION DEVICE IN OPTICAL FIBER



### Development Description

The etalon is designed for storing, reproducing, and transmitting the value of the device of polarization mode dispersion in optical fiber with polarimetric method on the optical radiation wavelength of 1550 nm in the range from 0.05 to 0.5 ps, and with interferometric method on the wavelengths of 1310 and 1550 nm in the range from 0.5 to 120.0 ps.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

- The etalon has metrological characteristics meeting the requirements of international standards.

- The accuracy characteristics of the etalon are 1.5 times better than analogical characteristics of the National Primary Special Etalon for the device of polarization mode dispersion in optical fiber (ГЭТ 185-2010) designed by All-Russian Research Institute for Optical and Physical Measurements (ARRIOPM) (Moscow, Russian Federation).

– The etalon corresponds to the world level by its metrological characteristics. The etalon is used in additional comparisons of national etalons of the Republic of Belarus and Russian Federation in accordance with the working plan of the technical committee “PR-Photometry and radiometry” of Euro-Asian Cooperation of National Metrological Institutions (COOMET).

#### Intellectual Property Protection

The etalon was approved as the National Etalon by the Decree of the State Committee for Standardization No. 44 dated 02.08.2019 and is included in the Register of National Etalons of the Republic of Belarus as NE RB 54-19.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Etalons and scientific instruments”, 2016–2020; subprogram “Etalons of Belarus”; task 2.13 “Create national etalon for polarization mode dispersion device in optical fiber”.

#### Field of Application

The etalon allows implementing the State Verification Schedule for tools used for polarization mode dispersion measuring in optical fiber and providing the uniformity of measurements of the given device in optical fibers and elements of fiber-optical communication systems and systems of information transfer used in communication, transport, oil, and gas industries of Belarus.

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## OPTICAL COHERENT TOMOGRAPHY DEVICE



### Development Description

PC-based optical coherent tomography device allows non-contact non-destructive registration of spectral- and polarization-contrast tomographic (bulk) images of semiconductor and dielectric materials, as well as biological tissues possessing transparency region in IR-range, with subsequent analytical evaluation of the morphology and functional state of the object according to these images. The design of the optical coherent tomography device makes it possible: i) to control the internal structure of materials and products that are semi-transparent in IR- range; ii) to detect low-contrast defects; iii) to determine the morphological properties of the object; iv) to investigate diagnostics of diseases and invasion degree of the skin; v) to develop mobile diagnostic systems.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The main technical parameters (wide spectral range and cross-section resolution) correspond to the best foreign analogical optical coherent to-



mography devices and there are no analogues at the domestic market of Belarus.

Distinctive features and advantages:

- wide spectral range;
- control of the internal structure of materials and products that are semi-transparent in IR- range;
- detection of low-contrast defects;
- determination of the morphological properties of the object;
- investigations on diagnostics of diseases and invasion degree of the skin;
- development of mobile diagnostic systems.

Technical parameters:

- operating spectral range: 650–1400 nm;
- cross-section resolution: 5.5 (up to 1)  $\mu\text{m}$ ;
- longitudinal resolution: < 3  $\mu\text{m}$  (up to 0.6)  $\mu\text{m}$ ;
- scanning area: 100 × 100 × 6 mm;
- maximal scanning frequency: 50 (up to 140) kHz;
- contrast: spectral-polarization.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Etalons and scientific instruments”, 2011–2015; subprogram “Instruments for science”; task 1.14 “Develop and produce the optical coherent tomography device for microelectronics and medicine”.

Field of Application

The device is used for investigations in industrial non-destructive testing and medical diagnostics. The device is designed for quality control of products made of semiconductor and dielectric materials as well as for the control of biological tissues functional properties.

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## COMPLETELY SOLID-STATE MULTIWAVE DIODE-PUMPED LASER SYSTEM



### Development Description

The laser system is a module construction, completely solid-state source of multimode pulsed radiation operating at one or more wavelengths from the set of 11 wavelengths in a wide spectral range and based on Nd:YAG, KGW,  $\text{Ba}(\text{NO}_3)_2$ , DKDP, BBO, and KTP crystals.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

This laser system has no analogues in the Republic of Belarus and abroad by its technical parameters:

- generation wavelength: 266, 355, 532, 559, 563, 588, 599, 621, 639, 1064, and 1571 nm;
- pulse energy (depending on the wavelength): 15–160 mJ;
- pulse repetition rate: 10, 20 Hz;
- pulse duration: 9–15 ns;

- beam divergence: 1.5–6.0 mrad;
- power consumption: < 950 W;
- weight without/with power supply: 58/69 kg.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Commercial contract with Saudi Arabia “Completely solid-state pulsed laser system generating in UV, visible, and near-IR spectral regions for application in the environmental protection, range-finding and life sciences” (June, 2014 – April, 2020).

#### Field of Application

The laser system can be used in scientific and applied investigations in life sciences (medicine and spectroscopy), environmental protection (lidar probing of the atmosphere, including range-finding in densely-populated areas), and in special spheres. The optical complex designed on the basis of this laser system is applied in Saudi Arabia for scientific purposes. The expansion of the development market is possible by the use of physical and technical profiles in higher education, as well as the design of a number of specialized laser systems based on the fundamental results obtained during the development.

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## PORTABLE PHOTOACOUSTIC METHANE DETECTOR



### Development Description

The photoacoustic detector is designed for continuous recording of low concentrations of methane in the air. The principle of its operation is based on the method of photoacoustic IR spectroscopy consisting in excitation of acoustic vibrations in a gas when it absorbs electromagnetic radiation. A single-mode thermoregulated laser diode with distributed feedback is used as a radiation source, the generation frequency of which corresponds to the spectral absorption lines of methane. The wavelength of the laser is adjusted near one of the lines using low-amplitude modulation of the diode pumping current. The modulation frequency corresponds to a half frequency of one of the acoustic resonances of a photoacoustic camera filled with a gaseous medium with methane admixture. Acoustic waves arising in the gas during the radiation absorption are recorded with an electret microphone at the resonance frequency of the photoacoustic camera.

The acoustic signal magnitude determines directly the methane concentration in the camera. The developed detector is portable, suitable for continuous measurements, including those in movement, and also has the ability of remote monitoring at long-term autonomous operation.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed methane detector possesses the characteristics corresponding to the best world analogues. The min gas sample required for the measurement does not exceed one cubic centimeter, the sensitivity of methane concentration measurements is not lower than 0.01 vol. %. The advantages are high selectivity of methane measurements in relation to other gases, as well as the low cost of manufacturing and operation, small dimensions and light weight.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Photonics, opto-, and microelectronics”, 2016–2020; task 1.1.01 “Development of the physical basis for the propagation and transformation of quasi-diffractionless vortex light beams of a new type in anisotropic, inhomogeneous, and scattering media and creation of innovative diagnostic optical-electronic devices on this basis”.

**Field of Application**

The photoacoustic detector is designed to detect small methane losses in mining and chemical industries, as well as for environmental monitoring of methane emissions into the atmosphere from various biological objects.

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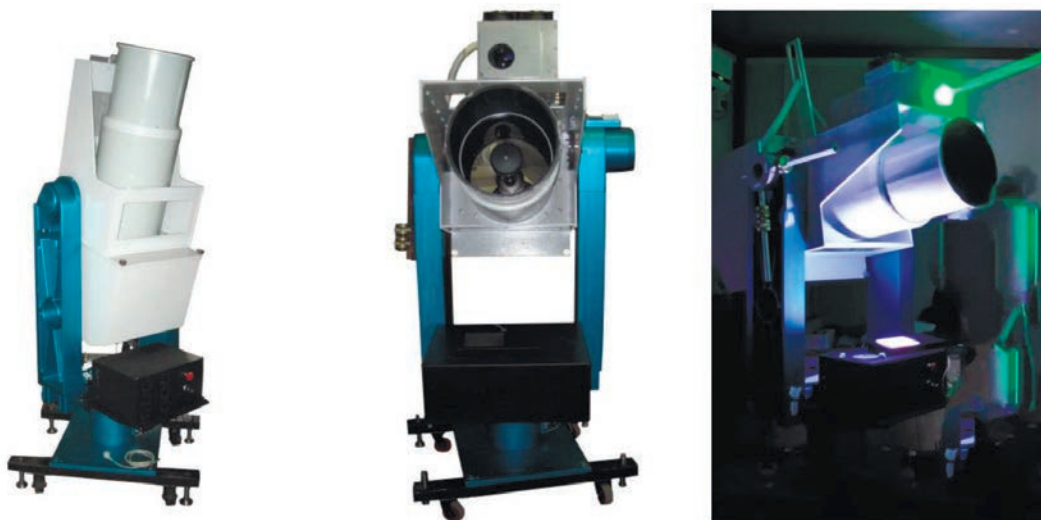
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## SCANNING MULTI-WAVELENGTH POLARIZATION RAMAN LIDAR FOR ATMOSPHERE AEROSOL AND CLOUDS PROBING



### Development Description

The automated scanning container-type multi-wavelength polarization Raman lidar is designed for measuring the tropospheric aerosol, clouds and mapping the air aerosol pollution of industrial centers in day and night time. The lidar is PC-controlled. The automated measurement mode is provided. The instrument variant with advanced functionality is produced by using two registration systems and installing lidar system modules in the hermetic housing for application of the device at lidar network stations in field conditions.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The lidar is a universal device with wide functionality. The lidar corresponds to the lidars of European Aerosol Research Lidar Network by its technical and performance characteristics.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Commercial contract “Development and creation of multi-wavelength aerosol scanning lidar”, 2012–2016.

**Field of Application**

Ecology, operational environmental monitoring and control of trans-boundary pollution transfer processes, mapping of aerosol pollution of an industrial center, measurement of optical parameters of the atmosphere in subsatellite experiments.

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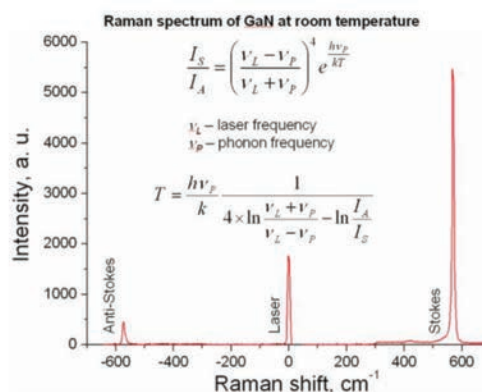
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## DEVICE FOR CONTROL OF TEMPERATURE FIELDS OF MICROWAVE MIC WITH LASER RAMAN SPECTROSCOPY METHOD



### Development Description

The developed device is designed primarily for mapping the temperature fields with the use of confocal microscopy of laser radiation Raman scattering in operating semiconductor instrument structures of MIC microwave with the submicron spatial resolution. The device has been developed and designed for simultaneous online registration of the Stokes and anti-Stokes components of the RS spectrum. The local temperature is determined by the ratio of the intensities of the Stokes and anti-Stokes components of scattered laser radiation making it possible to determine the local temperature without reference to a specific material or the ratio of elements in solid solutions. The existing Raman microscopy devices which allow measurements of the local substance composition without destructive effects on the Raman scattering spectrum are widely used in microscopy, biology, pharmacy, materials science, forensics, nanotechnology, semiconductor industry, and other fields of science, engineering, and technology.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

In the given development a new method for temperature fields determination is proposed, based on simultaneous registration of intensities of Stokes and anti-Stokes components of RS spectrum and temperature de-

termination not according to the spectral shift of the RS Stokes component, but according to the ratio of intensities of Stokes and anti-Stokes components. In this case, mechanical stresses inevitably presenting in semiconductor instrument heterostructures due to the difference in the crystal grating constants of adjacent layers of the structure and directly affecting the spectral position of the Stokes RS component (together with temperature) do not affect the value of the determined local temperature, thereby increasing the reliability of the measured temperature value. This is the main difference and advantage of this method. There are no commercially available Raman thermography systems.

Technical characteristics of the setup:

- max resolution (XYZ) 1  $\mu\text{m}$ ;
- temperature detection accuracy  $\sim 2^\circ\text{C}$ ;
- temperature registration range 0–500  $^\circ\text{C}$ .

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of critical standard technologies for the design and manufacture of nanostructured micro and optoelectronics products, devices and systems based on them and equipment for their production and testing” (“Luch”, 2016–2019); activity 5 “Development of equipment for internal technological control and testing of nanostructured microwave and optoelectronics products”; task 5.3 “Investigation of the possibility of creating a microwave MIS temperature field control device using laser Raman spectroscopy”.

**Field of Application**

The method makes it possible to determine local temperatures and their distribution over the surface with submicron spatial resolution in different operating modes in LEDs and on the output mirrors of semiconductor laser diodes, high-power microwave and power transistors, photoreceivers, surface acoustic wave devices, detectors, sensors, etc.

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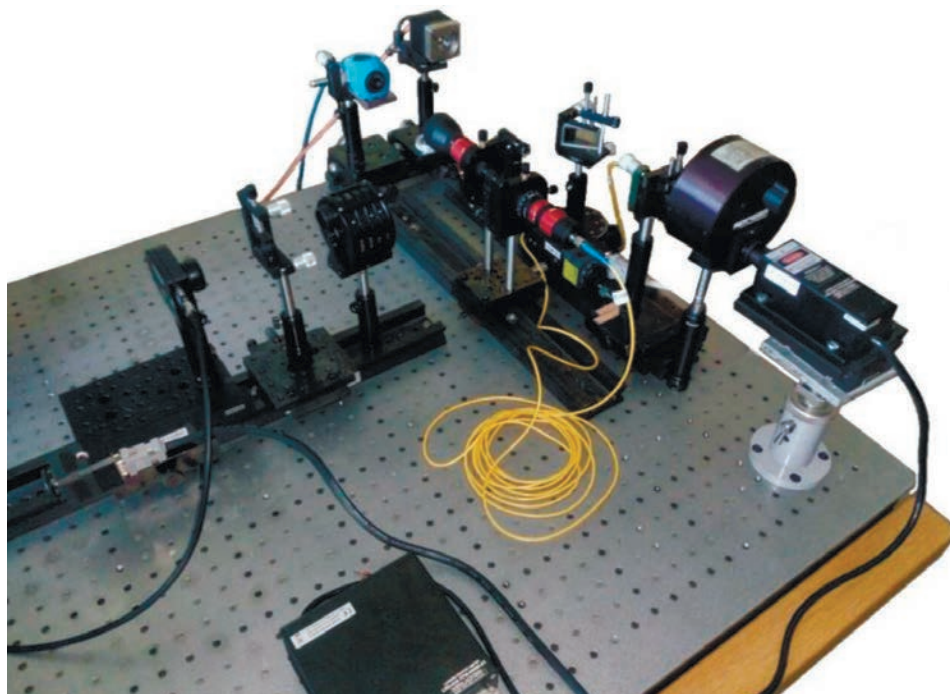
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## DEVICE FOR MONITORING THE WAVEFRONT SHAPE AND SPATIAL CHARACTERISTICS OF SOLID-STATE AND INJECTION LASERS RADIATION



### Development Description

The device is designed for measuring the wavefront and spatial characteristics (distribution of the power density (energy) of laser radiation in the beam cross section, effective beam sizes at a given propagation location, radiation divergence angles, and beam quality parameter) of solid-state and injection lasers radiation in the wavelength range from 190 nm to 20 microns.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The device is used to control the spatial distribution of the wavefront phase with simultaneous measurement of power density (energy) distribution of radiation in the same cross-section of the laser beam ensuring the repeatability and predictability of the laser beam behavior during its propa-

gation, as well as assessing the possible risks of radiation hazards of laser and optoelectronic technology. The device corresponds to the world scientific and technical level and the requirements for devices for monitoring the wavefront shape and spatial characteristics of optical radiation.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of critical standard technologies for the design and manufacture of nanostructured micro and optoelectronics products, devices and systems based on them and equipment for their production and testing” (“Luch”, 2016–2019), task 5.5 “Development of equipment for monitoring electrophysical and optical parameters of injection and solid-state lasers, including the equipment for long-term testing”.

#### Field of Application

The device is part of the metrological control base of laser and optoelectronic equipment in the Republic of Belarus and ensures the uniformity of measurements of the spatial characteristics of radiation of optoelectronic instruments manufactured and used in the Republic of Belarus, which reduces high costs of the tests conducted abroad.

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## DEVICE FOR MOLECULAR-BEAM EPITAXY OF NITRIDES



### Development Description

The device for molecular-beam epitaxy of nitrides has been jointly developed and designed by the Institute of Physics of the NAS of Belarus and JSC “NTO” (SemiTEq JSC) (Russian Federation) for the growth of heterostructures on substrates up to 100 mm in diameter.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Technical advantages of the device:

- epitaxy can be carried out both with plasma-activated nitrogen and ammonia (the nitrogen source in the first case is activated nitrogen, in the second case ammonia is decomposed on the substrate by temperature effect on nitrogen and hydrogen), therefore epitaxy can be carried out under significantly different growth conditions (both low- and high-temperature) providing advantages for obtaining high-quality layers;
- in the camera unit vacuum-connected to the growth camera, it is possible to affect the surface of the plates with two low-energy ion beams with different orientations (perpendicular to the surface and at the angle of  $45 \pm 15^\circ$ ) providing the opportunity to clean the substrate before growth, as well as to affect the near-surface areas of heterostructures in order to



improve their quality and control the orientation of the growth direction of the layers.

The best world-class results were obtained using this device:

- double AlGaIn/GaN heterostructures with 2D electronic gas have been grown on sapphire substrates surpassing the best analogues of the CIS countries and corresponding to the best world analogues (parameters of 2D electronic gas: layer resistance  $\sim 275$  ohms/sq., concentration  $\sim 1.25 \times 10^{13} \text{ cm}^{-2}$ , mobility  $\sim 2000 \text{ cm}^2/(\text{V}\cdot\text{s})$ );

- AlGaIn/GaN heterostructures with 2D electronic gas with a layer resistance of  $\sim 220$  Ohm/sq. were grown on sapphire substrates, which is a record for AlGaIn/GaN heterostructures and has no world analogues (electronic gas concentration  $\sim 1.55 \times 10^{13} \text{ cm}^{-2}$ , mobility  $\sim 1750 \text{ cm}^2/(\text{V}\cdot\text{s})$ ).

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of critical standard technologies for the design and manufacture of nanostructured micro and optoelectronics products, devices and systems based on them and equipment for their production and testing” (“Luch”, 2016–2019); task 1.3 “Development of standard manufacturing technologies for low-noise and linear amplifiers, as well as power amplifiers for frequency ranges from 4 to 40 GHz based on A3B5 nanostructured materials”; Commercial Contract No.618 with OJSC “Minsk Research Institute of Radiomaterials” “Development of methods of non-destructive luminescent testing and technologies of molecular-beam epitaxy of heterostructures of nanostructured materials for microwave amplifiers”, as well as innovation project “Development of material and technical base of the Applied-Research Laboratory of Molecular-beam epitaxy of nitrides of the Institute of Physics of the NAS of Belarus”, 2019–2021.

Field of Application

Nitride heterostructures epitaxy for high-power microwave transistors, diodes, LEDs, and semiconductor lasers, photo-receivers, surface acoustic waves based devices, detectors, sensors, ect.

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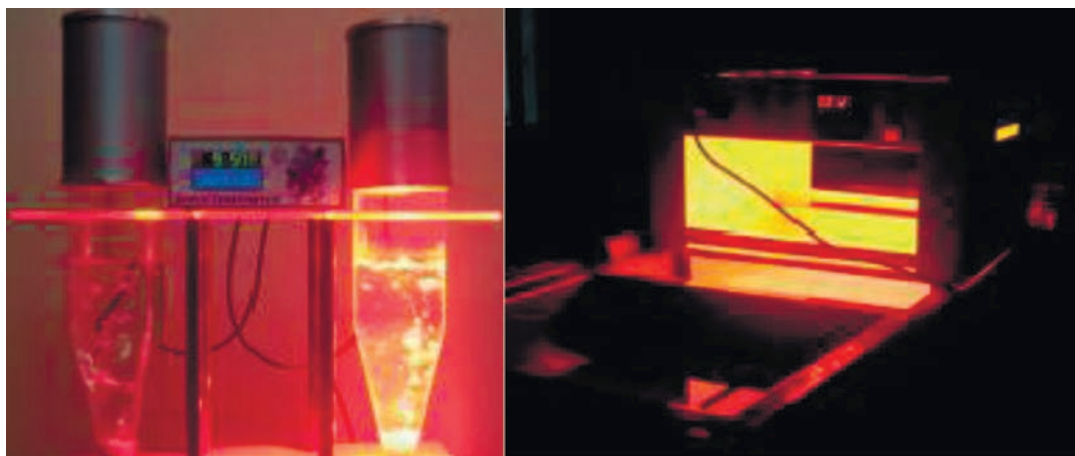
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## PHOTOSTIMULATORS FOR HYDROBIONTS



### Development Description

Photostimulators are designed according to comprehensive studies of the laws of action of optical radiation of visible and near-IR spectrum regions on roe and embryos of valuable species of fish (sturgeon, salmon, rainbow trout, sterlet) in order to increase the output of marketable products in the conditions of fish-farming industrial complexes by stimulating the economical qualities of fish seed material. The instrument can be used for stimulating the reproduction function of fish and fertilizing capacity of fish sperm (mobility, resistance, survivability). The operation principle of the instrument is based on stimulating effect of light from laser and LED sources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Photostimulators correspond to or surpass the best foreign analogues by their functional characteristics and technical parameters; there are no domestic analogues. The device is based on a modern elemental base of semiconductor lasers and LEDs of various spectral ranges. The advantage of the technology and the instrument is the optical light irradiation in conditions of technological equipment that is usually used in fish farms for incubating fish roe (tray-type incubators, Weiss incubators). The increased (compared to analogues) stimulating effect is achieved due to the optimal choice of the spectral range of radiation and its power density, modulation

of radiation intensity, synergism of the action of optical radiation of various spectral ranges.

As a result of the optical radiation exposure to embryos, the increase and synchronization of larval output from fertilized eggs is observed, as well as the increase in the resistance of hydrobionts to adverse environmental factors (toxicants, elevated or lowered temperature, lack of oxygen, etc.) ultimately leading to a significant increase in the size and weight of juvenile fish. The equipment and technologies that exclude the use of chemical growth stimulants are proposed. The products are environmentally friendly. The use of a photostimulator provides a 1.3-times increase of the reproductive function of fish, the fertilizing capacity of sperm, and the increase in the output of marketable products (by increasing the survival rate of roe and larvae, as well as increasing their viability) in conditions of fish-breeding industrial complexes.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

THE development is based on the investigations conducted within the Separate Project for Fundamental and Applied Investigations of the NAS of Belarus No. SR 20171028 “Development of laser-optical equipment and technologies to improve the efficiency of carp farming in pond aquaculture” (2017–2019), as well as State Research Program “Photonics and electronics for innovations”, 2021–2025; subprogram “Photonics and its applications”, task 1.6.1 “Development of laser-optical methods and theranostics devices using laser and LED sources for application in medicine, biotechnologies and agriculture”, No. SR 20210446 dated 31.03.2021.

#### Field of Application

The photostimulator can be used to activate the embryonation of fish, as well as to increase the mobility, preservation and fertilizing ability of fish spermatozoa in conditions of fish-breeding industrial complexes.

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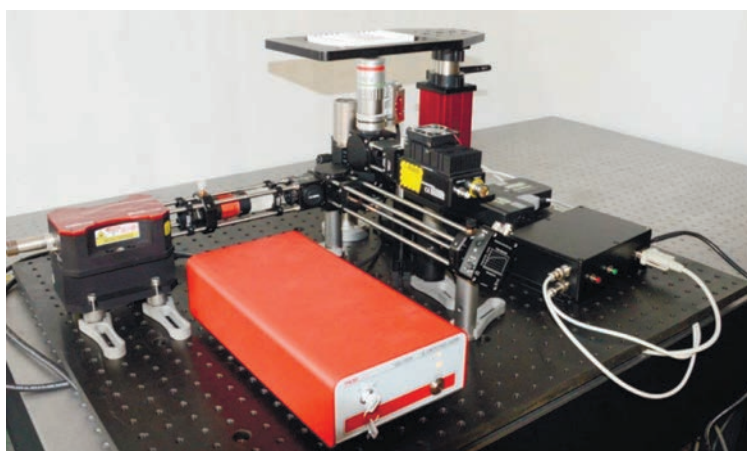
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## FLUORESCENT ANALYZER OF ULTRA-LOW CONCENTRATIONS OF BIOLOGICAL MOLECULES WITH FLUORESCENT LABELS BASED ON QUANTUM DOTS AND NANOPATES USING TWO-PHOTON LASER EXCITATION



### Development Description

The fluorescent analyzer of ultra-low concentrations of biological molecules is an important import-substituting equipment with a social orientation for the development of the latest methods and equipment for rapid diagnosis of viral and bacterial infections. In addition to the diagnosis of bacterial and viral diseases, with the help of this analyzer it is possible to solve such important tasks as conducting research on the resistance of pathogenic microflora to the action of antibiotics. Moreover, opportunities for semi-quantitative detection and quantitative determination of biochemical markers of various diseases in physiological fluids, as well as harmful substances in food and feed, are opening up, in accordance with the increasing needs of diagnostic medicine, food industry and agriculture.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The fluorescence analyzer allows detecting the presence of certain biological molecules exceeding a concentration of 10 pmol in test sample.

The maximum optical detection time is 15 minutes (strongly positive result). The radiation from 1030 nm IR subnanosecond laser, pulse duration of 500 ps and pulse repetition rate of 8–10 kHz is used as an excitation source. Type of fluorescent labels: quantum dots and nanoplates based on semiconductors of the AII BVI family. Spectral range of fluorescence of labels: from 0.55 to 0.7  $\mu\text{m}$ . The application of two-photon excitation in the fluorescence analyzer allowed to exclude the detection of fluorescence of unbound biomolecules and fluorescent labels in the entire sample volume and to reduce the limit-recordable concentration of substances. The use of quantum dots and quantum nanoplates of semiconductor compounds of the AII BVI family as fluorescent labels instead of conventional organic dyes allowed to increase the intensity of the fluorescent signal with a simultaneous decrease in the amount of detectable antibodies in the volume of the solution and the power of the pulsed IR laser for the optical excitation of nanoparticles. Thanks to this approach, an increase in the sensitivity of the method, a reduction in diagnostic time and a decrease in the maximum detectable concentration have been achieved. The device is created at a high world level and does not have an analogue in the CIS countries.

#### Intellectual Property Protection

None.

Name of the programme, subprogramme, project, business contracts under which the development was obtained

SSTP “Etalons and scientific instruments”, 2016–2020, subprogram “Unique scientific equipment”, task 1.13 “Develop and manufacture a fluorescent analyzer of ultra-low concentrations of biological molecules with fluorescent labels based on quantum dots and nanoplates using two-photon laser excitation”; SSTP “National etalons and high-tech research equipment”, 2021–2025, subprogramme “Equipment for prospective research”, task 1.13 “Develop and manufacture a fluorescent analyzer of ultra-low concentrations of biological molecules with fluorescent labels based on quantum dots and nanoplates using two-photon laser excitation”.

#### Field of Application

Diagnostics, medicine, food industry.

#### Contact Information of Organization-Developer

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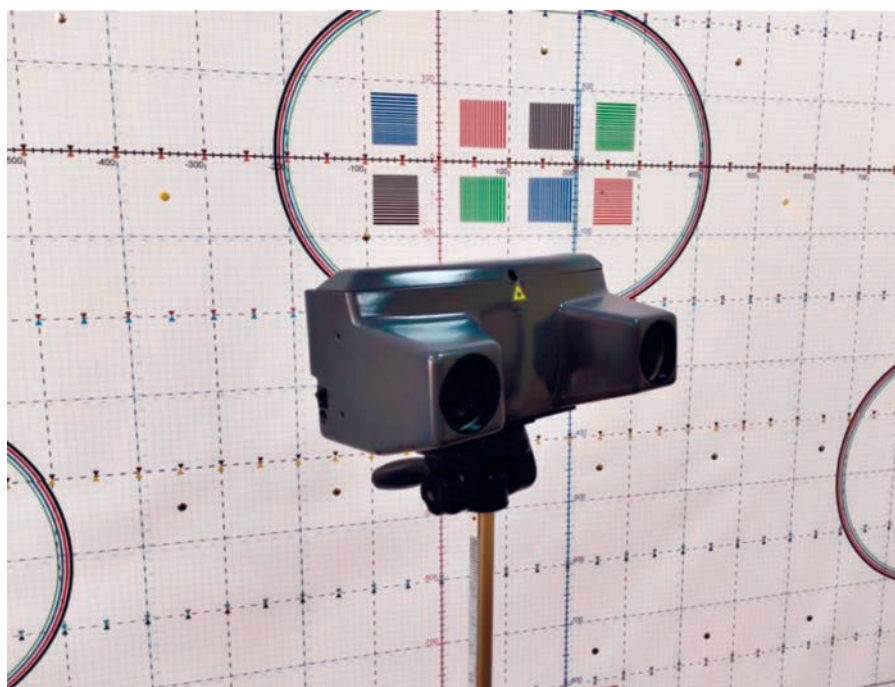
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State Scientific Institution "B. I. Stepanov Institute of Physics  
of the National Academy of Sciences of Belarus"

## SOFTWARE AND HARDWARE COMPLEX FOR FORENSIC PURPOSES BASED ON A DIGITAL CAMERA FOR DETERMINING THE DIMENSIONAL PARAMETERS OF OBJECTS



### Development Description

Software and hardware complex for forensic purposes for determining the dimensional parameters of objects. The complex is designed for photographing of objects or areas of terrain for carrying out linear measurements while ensuring investigative actions at incident sites. The developed technique makes it possible to measure distances and sizes of objects by correlation processing of digital photographic images without using a measuring object located in the measured zone.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The fluorescence analyzer allows detecting the presence of certain biological molecules exceeding a concentration of 10 pmol in test sample.



The maximum optical detection time is 15 minutes (strongly positive result). Radiation from 1030 nm IR subnanosecond laser, pulse duration of 500 ps, and pulse repetition rate of 8–10 kHz is used as an excitation source. Type of fluorescent labels: quantum dots and nanoplates based on semiconductors of the AIIIBVI family. Spectral range of fluorescence of labels: from 0.55 to 0.7  $\mu\text{m}$ . The use of quantum dots and quantum nanoplates of semiconductor compounds of the AIIIBVI family as fluorescent labels instead of conventional organic dyes allowed increasing the intensity of the fluorescent signal with a simultaneous decrease in the amount of detectable antibodies in the volume of the solution and the power of the pulsed IR laser for the optical excitation of nanoparticles. Thanks to this approach, an increase in the sensitivity of the method, a reduction in diagnostic time, and a decrease in the maximum detectable concentration have been achieved. The device is created at a high world level and does not have a domestic analogue or an analogue in the CIS countries.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Standards and scientific instruments”, 2016–2020, subprogram “Unique scientific equipment”, task 1.20 “Develop and manufacture a software and hardware complex for forensic purposes based on a digital camera to determine the dimensional parameters of objects”; SSTP “National standards and high-tech research equipment”, 2021–2025, subprogram “Equipment for advanced scientific research”, task 1.20 “Develop and manufacture a software and hardware complex for forensic purposes based on a digital camera to determine the dimensional parameters of objects”.

#### Field of Application

Criminology.

#### Contact Information of Organization-Developer

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**Republican Scientific and Production Unitary Enterprise  
“Center of LED and Optoelectronic Technologies  
of the National Academy of Sciences of Belarus”**

## **HIGHLY EFFECTIVE LED LUMINAIRES FOR GREENHOUSE HORTICULTURE LIGHTING**



### **Development Description**

LED greenhouse irradiators FLORA LED have the optimal radiation spectrum for photosynthesis ensuring high productivity of growing crops with minimum energy consumption in greenhouses.

The design is based on the technology for manufacturing highly efficient broadband LEDs with specified spectral characteristics created by State Enterprise “CLOET NAS of Belarus” during the period from 2015 to 2021.

Due to high technical and economic characteristics the designed products are in demand in the markets of the EAEU (Belarus, Russia, and Kazakhstan), EU (Serbia, North Macedonia, Italy), and other countries.

#### **Parameters:**

- Class of lighting distribution: Direct light;
- Class of energy efficiency: A+;
- Class of protection: I;
- Input voltage, V: 230;
- IP Rate: IP65;
- Frequency, Hz: 50;
- Power factor, min: 0.95;
- Operation temperature, C: +1...+40.

#### **Product line**

Product model	Wattage, W	Power of Radiation, W	Photon Flux, $\mu\text{mol/s}$	Dimension, mm	Weight, kg
FLORA LED 50 ДСП081 × 50004 УХЛ4	55	22	105	400 × 134 × 80	1.2
FLORA LED 100 ДСП082 × 50004 УХЛ4	110	44	210	700 × 134 × 80	1.9

FLORA LED 150 ДСП083 × 50004 УХЛ4	160	66	315	1000 × 134 × 80	2.3
FLORA LED 200 ДСП084 × 50004 УХЛ4	215	88	420	1300 × 134 × 80	2.7
FLORA LED 250 ДСП085 × 50004 УХЛ4	260	110	525	1600 × 134 × 80	3.2
FLORA LED 60/0.4 ДСП081 × 60004 УХЛ4	65	30	150	400 × 134 × 80	1.2
FLORA LED 120/0.7 ДСП082 × 60004 УХЛ4	130	60	300	700 × 134 × 80	1.9
FLORA LED 180/1.0 ДСП083 × 60004 УХЛ4	195	90	450	1000 × 134 × 80	2.3
FLORA LED 240/1.3 ДСП084 × 60004 УХЛ4	260	120	600	1300 × 134 × 80	2.7
FLORA LED 300/1.6 ДСП085 × 60004 УХЛ4	330	150	750	1600 × 134 × 80	4.0

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Based on the total characteristics the market cost of FLORA LED irradiators does not inferior to the best foreign analogues.

– FLORA LED irradiators allow designing the electric lighting system for greenhouses with high energy efficiency.

– FLORA LED irradiators are the source of optical radiation in a wide range of wavelengths, including photosynthetic active radiation ensuring a whole variety of photobiological processes occurring for plants.

– FLORA LED irradiators have a long life time: 10 years ( $L_{90F10} \geq 60.000$  h). The warranty period is 36 months.

– Competitive cost.

#### Intellectual Property Protection

A positive decision was received to issue a patent for the industrial design “LED module”. Application number f20220049 dated April 21, 2022

#### Name of the programme, subprogramme, project, business contracts under which the development was obtained

Innovative project “Design, pilot testing, preparation, and production of a number of highly efficient LED irradiators for greenhouse vegetable growing taking into account the characteristics of various crops and production targets”, 2016–2018.

#### Field of Application

FLORA LED irradiators are designed to create energy-efficient artificial lighting in industrial greenhouses and other closed ground cultivation facilities.

#### Contact Information of Organization-Developer

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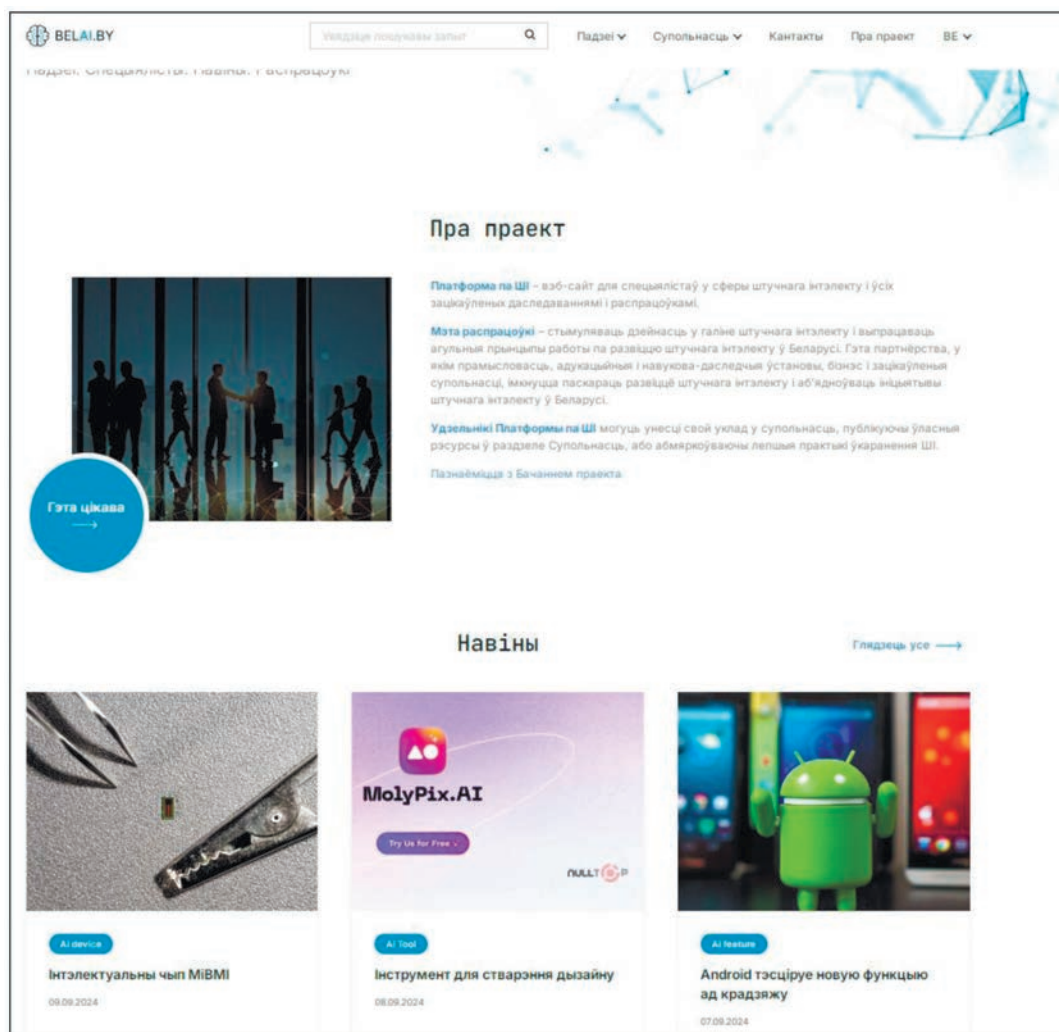
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State Scientific Institution  
“United Institute of Informatics Problems  
of the National Academy of Sciences of Belarus”

## BELAI.BY ARTIFICIAL INTELLIGENCE PLATFORM



Screenshot of the website page

### Development Description

Web application for artificial intelligence (AI) professionals and anyone interested in AI research and development. The concentration of the development of a common platform is based on creating a basis for communication, discussion, and presentation of programs, scientific, and practical events, and AI projects by domestic and foreign companies, teams, and

individual developers and practitioners in the field of AI to build a common policy and their work on the development of AI in the Republic of Belarus.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The platform is being developed in order to create momentum for the further development of AI and expand the possibilities of using the products of Belarusian developers. This will speed up the search for the necessary expertise for projects and the integration of interested teams. The task is to develop a full-fledged platform on which you can create a repository of thematic data for training personal models by students, scientists and other stakeholders. It will also be possible to share the results of work, hold contests, create personal services or propose an idea for implementation. Despite the fact that many countries have similar platforms, these tools have different tasks and goals. There is no single standard. Nevertheless, the project plans to implement in several stages of development the most complete list of necessary functionality and capabilities that correspond to the leading popular analogues in the industry. A database of AI developers, a data warehouse, an environment for testing models, a platform for discussing content and development are planned for implementation.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Digital and Space Technologies, Human Security, Society, and the State” for 2021–2025, subprogram “Digital Technologies and Space Informatics”, task 1.1.4 “Methods and Algorithms for Big Data Mining in Computer Information Processing Systems”.

**Field of Application**

Information services (service industry).

**Contact Information of Organization-Developer**

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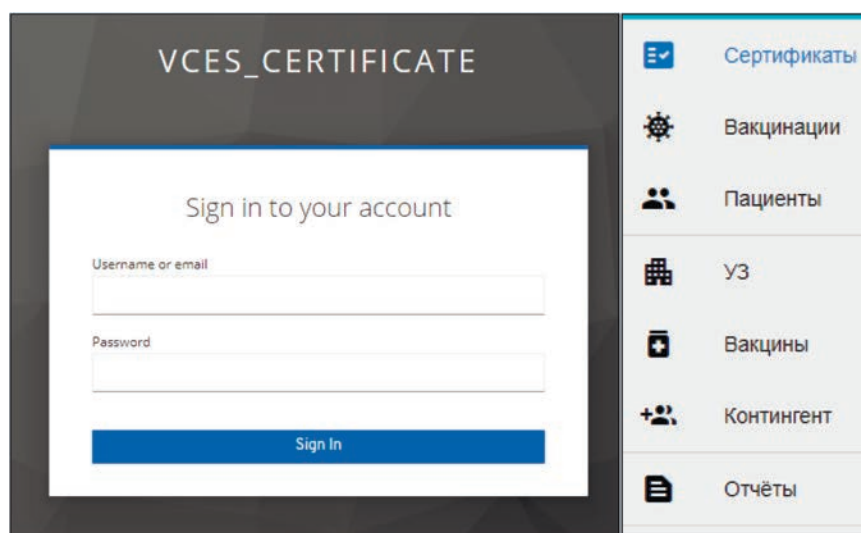
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**State Scientific Institution “United Institute of Informatics Problems  
of the National Academy of Sciences of Belarus”**

## **SOFTWARE PACKAGE “SOFTWARE PACKAGE FOR UNIFIED AUTOMATED INFORMATION SYSTEM FOR ACCOUNTING OF PERSONS VACCINATED AGAINST COVID 19”**



Screenshot of the app's home page

### **Development Description**

The software package “A set of software tools for unified automated information system for accounting for persons vaccinated against COVID-19” (SST UAIS) is designed to automate work processes related to the procedures for registration, collection, accumulation, storage, processing, and submission of summary reports on vaccination against COVID-19 of citizens of the Republic of Belarus, foreign citizens, and stateless persons who were vaccinated in healthcare institutions of the Republic of Belarus.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

It allows keeping records of citizens vaccinated against COVID-19, ensures the validity of the document confirming the fact of vaccination when traveling around the EAEU countries, while excluding cross-border transmission of personal data.

In addition, SST UAIS is the first stage in the development of the National Electronic Vaccination Platform, in which the Ministry of Health of the Republic of Belarus plans to post information on all measures of immunization of citizens. The project corresponds to the leading popular analogues in the industry.

#### Intellectual Property Protection

It was put into commercial operation at the Republican unitary enterprise “National Center for Electronic Services” (Minsk).

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Business contract with Belarusian Cloud Technologies LLC dated 18.02.2022 No. 213/656 on software development, in terms of developing a set of software tools for unified automated information system for recording persons vaccinated against COVID-19. Term: 18.02.2022 – 31.10.2022.

#### Field of Application

Information services (sphere of services).

#### Contact Information of Organization-Developer

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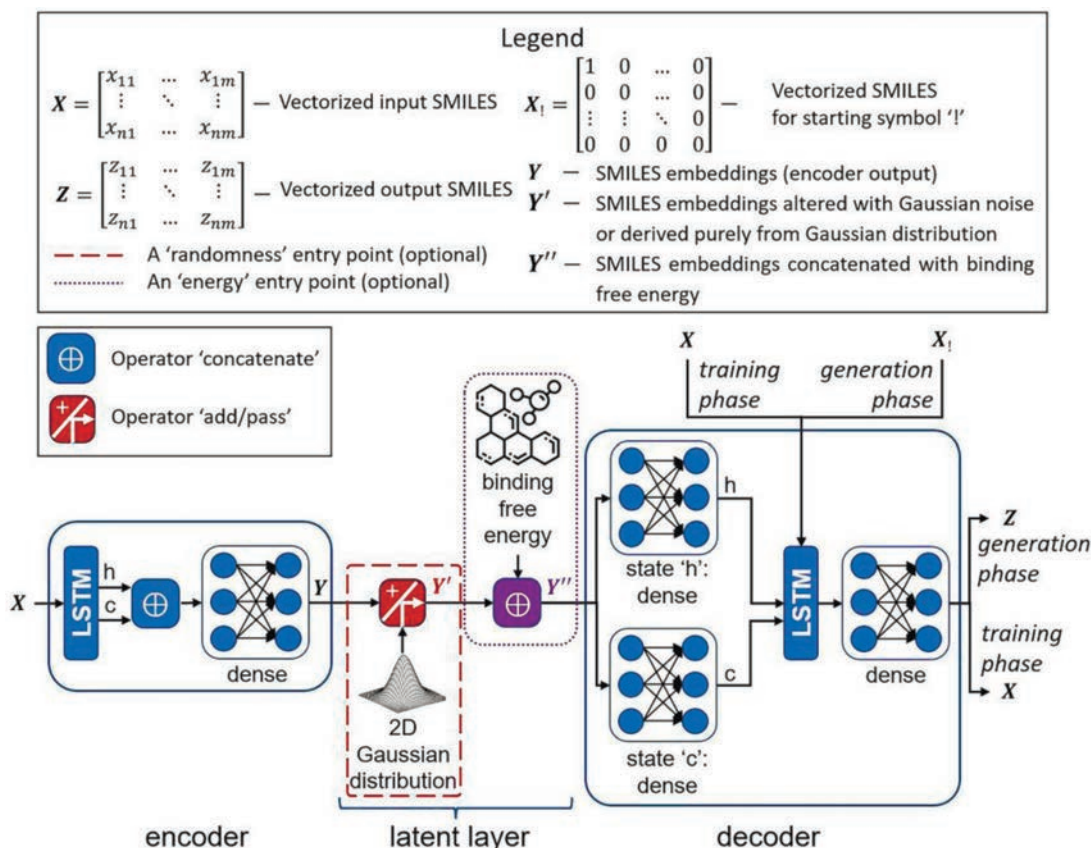
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State Scientific Institution “United Institute of Informatics Problems  
of the National Academy of Sciences of Belarus”

## COMPUTER SIMULATION OF POTENTIAL MEDICINAL PRODUCTS



### Development Description

A generative deep learning neural network has been developed for the computer design of potential inhibitors of the main protease (Mpro) of the SARS-CoV-2 coronavirus, which plays an important role in the replication and transcription of the virus. The neural network was trained and tested and the results of its work were evaluated. Using the developed neural network, a computer design of potential inhibitors was carried out Mpro SARS-CoV-2.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The neural network allows the generation of new chemical compounds that effectively interact with the main Mpro protease of the SARS-CoV-2 coronavirus.

Based on the data obtained, it was shown that the identified compounds can be used as basic structures for the development of new effective drugs against COVID-19; one of the main directions for using the results obtained is the creation of new drugs against COVID-19 based on the designed compounds. Corresponds to the best world analogues.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

BRFFR project No. F21KCOVID-002 “Identification of potential inhibitors of the main protease of the SARS-CoV-2 coronavirus using deep learning and molecular modeling technologies”, 2021–2023.

**Field of Application**

Information services (service sector).

**Contact Information of Organization-Developer**

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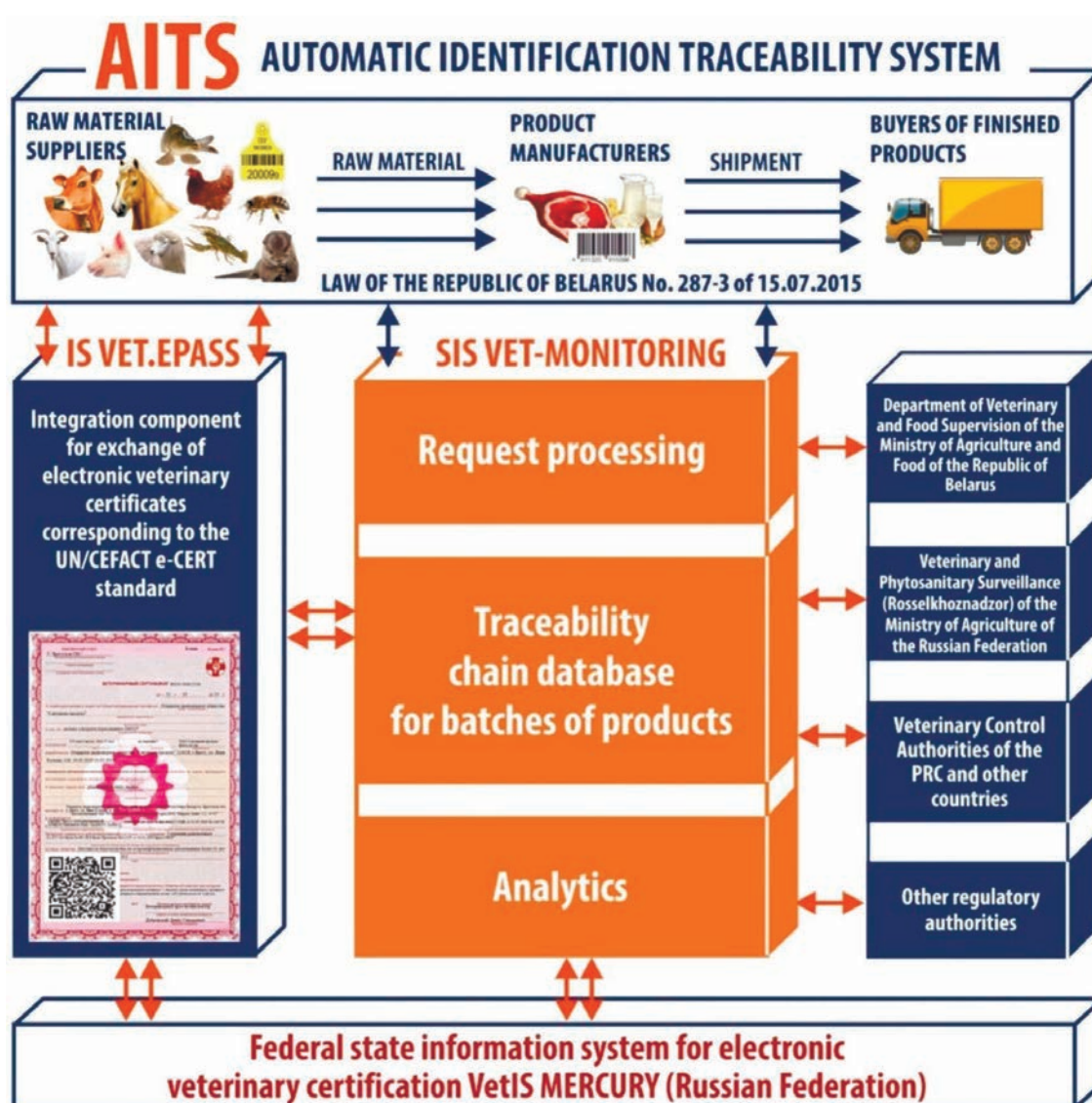
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**The Scientific and Engineering Republican Unitary Enterprise  
“Intersectoral Scientific and Practical Centre for Identification Systems  
and E-Business Operations”**

**AUTOMATED INFORMATION SYSTEM  
FOR IDENTIFICATION, REGISTRATION, TRACEABILITY  
OF ANIMALS AND PRODUCTS OF ANIMAL ORIGIN  
(AITS) INTEGRATED WITH THE RUSSIAN STATE  
INFORMATION SYSTEM FOR ELECTRONIC VETERINARY  
CERTIFICATION “MERCURY”**



### Development Description

In compliance with the Law of the Republic of Belarus No. 287-3 “On Identification, Registration, Traceability of Farm Animals (Herds), Identification and Traceability of Products of Animal Origin” dated July 15, 2015 SIS AITS (Animal Identification Traceability System), the state information system for identification, registration, traceability of farm animals (herds), identification and traceability of products of animal origin has been created, is functioning and is being further developed.

AITs is a tool for state regulation and management in the field of identification, registration, traceability of farm animals (herds), identification and traceability of products of animal origin. AITS contains individual electronic passports of animals (or herds). Each passport contains full information about the animal starting from its birth, such as its location, movements, health, veterinary welfare (including vaccinations, diseases and medications used for treatment) and other information related to the health of the animal that may affect the products produced from it. Livestock owners record a set of significant events related to each animal (herd) throughout its life in the electronic passports, thus ensuring the traceability of the animals. This database is available to regulatory agencies as well as processors so that they can view the data, import it into their traceability information systems (accounting systems) and trace the animals that are the source of raw materials for their products. The traceability of products of animal origin by means of AITS is based on using the data about raw materials, batches of finished products and information on all shipments of these products to market participants both in Belarus and abroad. This data is generated daily by the suppliers' traceability information systems (or accounting systems) and sent via web services or web interface to the relevant registers. AITS interacts with the state information system for electronic veterinary certification “Mercury” (Russian Federation) through the integration component VET.EPASS, which allows automatic exchange of electronic veterinary certificates complying with the international e-CERT standard (recommended by the UN/CEFACT) for each shipped batch of controlled products. Such mechanism ensures that electronic veterinary documents accompany shipments of animal products both within the country and to the EAEU countries and the Russian.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

AITs is the only state-level information system in the Republic of Belarus, as well as in Europe and Asia, that provides a comprehensive approach to creating “end-to-end” food chain safety – from animals to finished meat and dairy products.

## Intellectual Property Protection

Know-how – Intellectual Property Protection.

### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Project “Creation of a state information system for collecting, analyzing and exchanging data on the traceability of controlled products in order to implement the Union program for the integration of information systems of state regulatory bodies in terms of veterinary control” – SIS “Vet-monitoring” (2022–2023).

### **Field of Application**

IT-industry, mathematics, traceability of goods and food safety, agro and industrial complex.

### **Contact Information of Organization-Developer**

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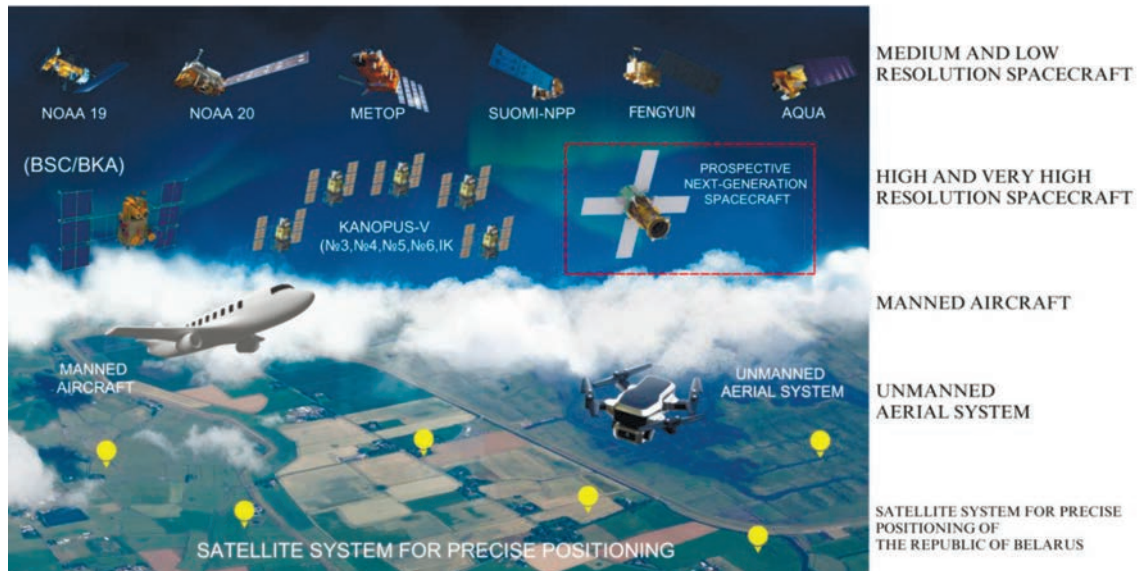
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## Scientific and Engineering Republican Unitary “Geoinformation Systems”

MULTI-LEVEL BELARUSIAN SPACE SYSTEM  
FOR EARTH REMOTE SENSING (MBSSERS)

## Development Description

MBSSERS is a geographically distributed information system for receiving, processing, and exchanging information, functionally combining information resources of remote sensing of the Earth (ERS) and derivatives from them circulating at the functional levels of the system: receiving, processing, and disseminating remote sensing data (RS). The functional levels of MBSSERS consist of corresponding subsystems that are scalable depending on the type of geospatial data obtained and the expansion of the list of tasks to be solved based on remote sensing data. The system allows getting high precision images of the Earth's surface in the visible and near-infrared spectral ranges with a spatial resolution of 2.1 m (panchromatic) and 10.5m (multispectral). Preliminary and thematic image processing and its delivery to consumers. MBSSERS consists of the following subsystems:

- Data collection and coordination subsystem;
- Earth observation data backup repository of the Central Command of Armed Forces Subsystem;
- Monitoring and response subsystem in case of disasters' threats or its arising;
- Land inventory monitoring subsystem;



- Forest inventory monitoring subsystem;
- Hydrometeorological safety subsystem.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The only supplier in the Republic of Belarus of images of the Earth's surface in the visible and near-infrared spectral ranges with a spatial resolution of 2.1 m (panchromatic) and 10.5 m (multispectral). Socio-economic impact of the system implementation:

- Increasing the efficiency of solving problems by user subsystems due to creation of new technologies in the areas of activity of these subsystems;
- Ensuring the redundancy of the remote sensing database to increase the reliability of the system for MBSSERS operational provision of data for ensuring national security, expanding the range of solved applied issues based on the use of Belarusian Spacecraft (BS) remote sensing data, the upcoming BS, aviation and ground-based remote sensing equipment;
- Ensuring the functioning of consumer geoinformation technologies when monitoring the condition of instances and territories using space, air, and ground information;
- Increasing the reliability of the system for the operational provision of MBSSERS data, reducing the time required to create topographic and geodetic information tools in order to ensure national security, expanding the range of applied issues to be solved based on the use of remote sensing data of BS, as well as remote sensing data obtained by aviation and ground-based facilities;
- Generation of a unique information space for the authorities of the state system for emergency prevention and disaster response based on remote sensing data of MBSSERS;
- Increasing the accuracy and efficiency of hydrometeorological forecasting and analysis of the actual state of hydrometeorological and radiation-ecological parameters using space, aviation, and ground remote sensing facilities, as well as technologies for its data processing;
- Increasing the efficiency of the public administration system providing the Ministry of Emergency Situations of the Republic of Belarus, the Ministry of Defense of the Republic of Belarus, the Ministry of Natural Resources and Environmental Protection of the Republic of Belarus, and the State Committee for Property of the Republic of Belarus with objective space information on current conditions of ground infrastructure facilities.

**Intellectual Property Protection**

MBSSERS was designed as a single instance and is aimed to increase the level of security of the population and the territory of the Republic of Belarus. No Intellectual Property Protection required.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

R&D project: “Creation and development of the Multi-Level Belarusian Space System for Earth Remote Sensing using space, aviation, and ground-based means of the Earth remote sensing and relevant technologies for its application”; subprogram 7 “Exploration of outer space for peaceful purposes” of State Program “Science-based technologies and engineering”, 2016–2020.

**Field of Application**

Detection and monitoring of emergency situations, meteorological forecast, crop yield forecast, compiling vegetation maps, etc.

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Scientific and Engineering Republican Unitary Enterprise  
"Geoinformation Systems"

**DISTRIBUTED SYSTEM FOR ACQUIRING, PROCESSING,  
AND DISSEMINATING OPERATIONAL SPACE DATA  
FROM SPACECRAFT ("AQUA", "SUOMI NPP", "NOAA 20",  
"METOP", "FENGYUN-3")**



**Development Description**

The Distributed System for Acquiring, Processing, and Disseminating Operational Space Data from Spacecraft (the DSAPD MS) is capable of acquiring, processing, storing, and disseminating the Earth remote sensing data from 12 meteorological satellites to be provided for the Ministry of Emergency Situations of the Republic of Belarus, state institution "Republican Center for Hydrometeorology, Radioactive Pollution Control, and Environmental Monitoring" and other consumers up to 26 times a day. The system carries out: pre-processing of acquired data; formation and storage of core data as set and descriptive information thereof; automatic detection of thermal anomalies and determination of their parameters for the territory of the Republic of Belarus and the cross-border area of adjoining states. The results, in terms of thermal anomalies displayed on a digital map of the area, are transferred to the units of the Ministry of Emergency Situations of the Republic of Belarus within 10 minutes after the end of the acquisition session, and published on the Internet [Meteoeye.gis.by/hotspots](http://Meteoeye.gis.by/hotspots); computation and sequential tracking of the NDVI value throughout the territory of Belarus, forecasting the yield of grain crops based on this value; providing users with query, visualization and access facilities to core data assets based on the geoportal solution on the web [Meteoeye.gis.by](http://Meteoeye.gis.by).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The system has no analogues or alternatives in the Republic of Belarus in terms of its goals, tasks to be solved, and technical implementation.

**Intellectual Property Protection**

State Register of Rights to the Results of the Scientific and Scientific and Technological Activities records the following details on ownership rights to the components of the DSAPD MS:

- “Subsystem of acquiring operational space data SBKI (СБКИ).464349.001”, registration number 3449, registration date: February 23, 2021;
- “Software-hardware complex of a prototype subsystem for processing and disseminating operational space data SBKI.466535.044”, registration number 3450, registration date: 23.02.2021;
- “Software complex for space data dissemination of a prototype subsystem for processing and disseminating operational space data SBKI.30062-01”, registration number 3451, registration date: 23.02.2021;
- “Complex for detecting thermal anomalies of a prototype subsystem for processing and disseminating operational space data SBKI.30063-01”, registration number 3452, registration date: 23.02.2021;
- “Software complex for forecasting grain crop yields of a prototype subsystem for processing and disseminating operational space data SBKI.30064-01”, registration number 3453, registration date: 23.02.2021.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-Tech Technologies and Engineering” for 2016–2020, subprogram 7 “Exploration and use of outer space for peaceful purposes”, task 41 “Creation of a distributed system for acquiring, processing, and disseminating operational space data from spacecraft (“AQUA”, “SUOMI NPP”, “NOAA 20”, “MetOp”, “Fengyun-3”)”.

**Field of Application**

Detection and monitoring of emergency situations, meteorological forecast, crop yield forecast, compiling vegetation maps.

**Contact Information of Organization-Developer**

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Open Joint Stock Company “Minsk Research Institute of Radio Materials”

## STRAIN SENSOR



### Development Description

The strain sensor (SS) is designed to monitor the deformation (compression) amount of a vehicles axle under the load and provide information via a standard CAN 2.0 digital interface. The sensor is used as part of a vehicle overload protection system and can also be used to record weight parameters in urban municipal vehicles.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Distinctive features and advantages: the presence of a built-in measuring module that performs the functions of amplifying the output signal from a strain gauge bridge, a 24-bit analog-to-digital converter, a 32-bit microcontroller that calculates the load value in kg using constants stored in the microcontroller's memory when the user performs the sensor calibration procedure; correction of the load calculation result taking into account the influence of ambient temperature using a built-in temperature sensor; output of load and temperature measurement results in an error-proof digital format (CAN 2.B), small overall and installation dimensions, resistance to external mechanical factors during the operation.

The sensor mount ensures high reliability and the necessary reserve of pressing force of the sensor's working surfaces to the object and eliminates violations of the sensor calibration associated with the "slippage" effect when exposed to extreme loads. Corresponds to the best foreign analogues.

**Intellectual Property Protection**

Patent of the Republic of Belarus No.12262 for the utility model “Strain Sensor”, Patent of the Russian Federation No.201365 for the utility model “Strain Sensor”.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Initiative development at the expense of the organization.

**Field of Application**

Components, assemblies, and equipment of vehicles. The economy branch is mechanical engineering and instrument making. Machine-building enterprises producing vehicles, municipal, agricultural, construction equipment, timber trucks, etc.

**Contact Information of Organization-Developer**

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Open Joint Stock Company “Minsk Research Institute of Radio Materials”

## THERMOELECTRIC RADIATION RECEIVER



### Development Description

Heat flow sensor (thermoelectric radiation receiver) based on the Seebeck effect. It is designed to measure the power of radiant energy flow. Characteristics: sensitivity: 38.6–49.8 V/W for heat flow power 0–500 W/m<sup>2</sup> and 93.9–104.3 V/W for heat flow power 500–4000 W/m<sup>2</sup>, response time – 0.04 s.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The use of planar technology and double-sided photolithography make it possible to increase the sensitivity and reduce the weight and size characteristics compared to known solutions. Non-stoichiometric silicon nitride (Si<sub>x</sub>N<sub>y</sub>), which has a lower internal tension than silicon nitride (Si<sub>3</sub>N<sub>4</sub>), was used to create the sensor crystal membranes. Correspond to the best foreign analogues.

### Intellectual Property Protection

Patents of the Republic of Belarus for utility model No. 12665, 12193 “Thermoelectric radiation receiver”.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Process Development Work “Develop a technology for creating a highly sensitive sensor based on the Seebeck effect to measure the power of radiant energy flow” of Scientific-Technical Program of the Union State “Development of integrated technologies for creating materials, devices, and key elements of space vehicles and promising products of other industries”, 2016–2020.

### Field of Application

Instruments for measuring the amount of heat.

### Contact Information of Organization-Developer

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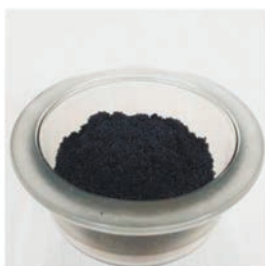
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DEPARTMENT  
OF PHYSICAL  
AND TECHNICAL SCIENCES

State Scientific and Production Association "Scientific and Practical Center  
of the National Academy of Sciences of Belarus for Materials Science"

## NOVEL METHOD OF PRODUCING GRAPHENE-LIKE MATERIALS



Graphene obtained by the  
new method



Prototype supercapacitor  
containing graphene



Graphene-based  
honeycomb material

### Development Description

Method is based on two basic reactions: obtaining a compound of alkali or alkaline-earth metals and graphite in a liquid ammonia medium and their subsequent decomposition to form graphene and related materials.

By varying the synthesis conditions of the incorporation compounds and their subsequent heat treatment using this approach, the following types of new carbon materials are obtained:

- low-layer graphene (1–3 layers);
- functionalized graphene;
- graphene materials with cellular pore structure;
- restructured graphite of high density;
- restructured graphite composites with metals, ceramics and polymers.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

- High productivity per unit reactor volume;
- no toxic waste requiring disposal;
- low cost of synthesis;
- the possibility of implementing large-scale profitable industrial production;
- high structural perfection of graphene obtained by this method compared to known chemical methods for its production;
- low graphene oxidation of the product (0.1 % oxygen), which is extremely important when used in sodium-ion and lithium-ion batteries;

- possibility of functionalization during synthesis under mild conditions;
- possibility of creating cellular structures based on graphene without using binding components or adhesives.

The known analogues are characterized either by high quality of graphene but low productivity of the synthesis (as in chemical vapour deposition or different types of mechanical exfoliation methods), or by high productivity of the synthesis but low purity and structural quality of graphene (as in the methods based on graphite oxidation).

#### Intellectual Property Protection

The development is protected by a number of patents (BY17336; BY15700; BY13644; BY13642), a certain part of the development, which is of commercial importance, is not disclosed.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

- SRP “Physical materials science, new materials and technologies” for 2016–2020, subprogram “Nanomaterials and nanotechnology”, task 2.60 “Development of synthesis methods and research of properties of composite structures based on electrically conductive nanofibers, nanoplates, and nano-frameworks for use in electronics, photovoltaics, and electrical engineering”;
- Contract for development work “Manufacture and transfer of composite material with size of (1500 × 1000 × 0.35) mm”, 2020. Customer – OJSC “SvetlogorskKhimvolokno”;
- State Program “High-Tech Technologies and Engineering” for 2021–2025, subprogram 7 “Development of electric transport”, task 5 “Develop components of sodium-graphene batteries and create a prototype of a storage device on their basis”.

#### Field of Application

Cathode and anode components in sodium ion batteries, sorbents to eliminate pollution of water and soil from oil and oil products, high-temperature heat insulation, composite materials with polymers having high mechanical characteristics, modifiers in lubricants, manufacturing of heat-releasing elements for electrical and electronic devices, resistive elements for flexible heaters, gas sensors.

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State Scientific and Production Association “Scientific and Practical Center of the National Academy of Sciences of Belarus for Materials Science”

## HIGHLY EFFICIENT ELECTROMAGNETIC PROTECTION SYSTEMS FOR ON-BOARD INSTRUMENTS OF ROCKET AND SPACE VEHICLES WITH IMPROVED OPERATIONAL CHARACTERISTICS



The scanning spectrometer unit of BepiColombo spacecraft (a) and elements of navigation equipment of rocket and space technology with electromagnetic protection (b)

### Development Description

The technology and materials have been developed to ensure electromagnetic protection and electromagnetic compatibility of on-board rocket and space equipment units. Within the framework of the international Bepi-Colombo project for the exploration of the Mercury planet, electromagnetic shields (a) were formed on standard housings of scanning spectrometer units using the developed technology. The use of new materials and technology has completely solved the problem of electromagnetic compatibility: in the frequency range from 10 Hz to 10 MHz the electromagnetic interferences were completely removed and thus the “magnetic” operating conditions of the spacecraft were provided. Random broadband vibrations of the rocket body occur in the Earth’s external magnetic field. These fluctuations negatively affect the operation of sensitive sensors, gyroscopes, angular velocity sensors, and other navigation devices. The application of the developed technology has significantly improved the operational characteristics of navigation equipment (b).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed electromagnetic protection technology allows:

- forming electromagnetic protection on standard housings and blocks of electronic equipment in a single technological cycle, varying the thickness in wide ranges, ensuring high manufacturability of the forming process and rigid fixation relative to the body of the part;
- ensuring high shielding efficiency in the frequency range 10–107 Hz;
- coordinating the requirements for weight and size parameters, which is often impossible according to the traditional technology of manufacturing shields from massive materials. The existing analogues in the world are foils or constructions in the form of housings for equipment that have a narrow operating frequency range. The existing solutions do not allow integrating electromagnetic protection into devices without changing the design, including weight and dimensions.

#### Intellectual Property Protection

Patents of the: USA: US6001282A, US10718835B2, US10718835B2; Japan: JP5902693B2, JP7018440B2.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

- Scientific-Technical Program of the Union State “Development of space and ground-based means of providing consumers of Russia and Belarus with Earth remote sensing information” (“Monitoring-US”, 2013–2017); task 2.4 “Develop technology for the formation and creation of experimental samples of shields to protect on-board spacecraft systems from electromagnetic influences of artificial and natural origin”.
- Scientific-Technical Program of the Union State “Development of integrated technologies for creating materials, devices, and key elements of space vehicles and promising products of other industries” (“Technology-US”, 2016–2020); task 1.2.1.1 “Develop a technology for the formation of electromagnetic shields, including transparent ones in the visible range, ensuring compatibility and protection of elements and blocks of the spacecraft from the effects of electromagnetic radiation”.

#### Field of Application

Protection of electronic components, electronic and information equipment, and biological objects from external electromagnetic impacts.

#### Contact Information of Organization-Developer

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State Scientific Institution “V. A. Belyi Metal-Polymer Research Institute  
of the National Academy of Sciences of Belarus”

## FLUOROPLASTIC COMPOSITE MATERIAL SUPERFLUVIS+



### Development Description

The material is a composite of fluoroplastic-4 (PTFE) and grinded carbon fibers pre-treated with chemically active plasma. Designed for the manufacture of various anti-friction parts for use in friction units without lubrication, in contact with chemically active substances and food products, at temperatures up to +260 °C, including: sealing rings of moving and fixed joints, piston rings, slip bearings.

Depending on the composition, the material is produced in two grades: Superfluvis+ and Superfluvis 10+. The material is produced in the form of blanks (rods, bushings, and disks) and a pressing composition.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The anti-friction fluoroplastic composite Superfluvis + exceeds the most used analogue F4K20 by 2–3 times in wear resistance, 1.5 times in rigidity,

and 1.5 times in thermal conductivity. The use of Superfluvis+ in friction units ensures the increase in the service life and reliability of equipment, reduction in the number of repairs and downtime of equipment by 2–2.5 times compared to parts made of F4K20, when used in chemical and oil and gas industries.

#### Intellectual Property Protection

Patent of the Republic of Belarus No. 22089, patent of the Republic of Belarus No. 22115.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of innovative technologies and equipment for the production of competitive composite materials, matrices and reinforcing elements for 2012–2016” (“Kompomat” code), state contract No. IOBK-2012-5 “Development of anti-friction fluoroplastic composites for the chemical and oil and gas industries” dated December 21, 2012.

#### Field of Application

The development is used in the chemical and oil and gas industries, namely in friction units of compressor and pumping equipment, and ball valves.

#### Contact Information of Organization-Developer

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State Scientific Institution “V. A. Belyi Metal-Polymer Research Institute  
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## FLEXIBLE POLYMER TUBES FOR PNEUMOSYSTEMS



### Development Description

Designed for use as flexible pipelines in pneumatic brake systems of tractors and vehicles. The pipes are produced by continuous screw extrusion from extrusion impact-resistant polymer composite of grade “Etamid EA-EU”.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues):**

Advantages:

- working pressure 7 MPa;
- operating temperature range is  $-60...+100$  °C;
- can be made colored in any color and of various sizes;
- currently, pipes of sizes from  $4 \times 0.75$  mm to  $16 \times 2.5$  mm are available. The tubes are produced from the impact-resistant composite “Etamid EA-EU” based on PA6 and used to substitute similar tubes based on a highly priced imported polyamide.

### Intellectual Property Protection

Technical specifications TR BY 400084698.274-2015 “Polyamide Pipe”, with cor. No. 1.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Minsk Tractor Plant OJSC (Contract No. I45/2021 dated 07.04.2021), Gomselmash OJSC (Contract No. 379/3182021/I70/2021 dated 05.20.2021).

**Field of Application**

Transport and automotive industry.

**Contact Information of Organization-Developer**

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## PADS OF RAIL FASTENERS FOR HIGH-SPEED RAILWAY LINES AND HEAVY TRAFFIC



KB-65 rail fastening pads (rail seat  
and above cross-sleeper)



ARS rail fastening pad

### Development Description:

Polymer composite materials (such as ECM-D) and structures of KB, ARS, GBR, SB-3 rail fastening pads, etc. for high-speed and heavily loaded railway lines. The pads comply with the requirements of НБ ЖТ ЦП 149-2003 (category II, PD execution).

They are produced by a high-performance method of injection molding, which ensures their high quality and stability of geometric sizes. The distinctive feature of the developed materials for pads is the stability of their dynamic mechanical properties in the temperature interval from  $-60$  to  $+60$  °C, as well as high resistance to alternating loads, exposure to oil products, and climatic aging.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Technical characteristics of pads made of EKM-D material:

- shor A hardness, unt.: 86–90;
- glass temperature of the material of the pads, °C:  $-75$ ;
- range of operating temperatures, °C: from  $-60$ ... $+60$ ;
- vertical stiffness in the bonding node (depending on the grade of composite), kN/mm: 120–300.

The pads made of EKM-D material passed stand tests at VNIIZHT OJSC (Moscow) withstanding 10 million loading cycles without destruction. Currently, they are tested in real operating conditions on lines with heavy traffic

(direction Moscow – Kursk). More than 200 thousand pcs of SB-3 pads were delivered for the needs of the Belarusian railway. They differ from the SB-3 polyurethane fasteners currently used in Belarus by the extended to lower temperatures (-60 °C) service temperature range; and outperform by an order of magnitude similar rubber-based fasteners in terms of payload capacity and service life.

#### Intellectual Property Protection

Technical Specifications TR BY 400084698.240-2014 “Damping pads of rail fastening of high-speed railways “PSZT”; Patents of the Republic of Belarus: No. 17262, 17263. Patents of the Republic of Belarus: No. 17262, 17263

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

– Program of the Union State “Development of innovative technologies and equipment for the production of competitive composite materials, matrices and reinforcing elements for 2012–2016”, code “Compomat”, task “Compomat-2” (agreement No. UVK-2012-2 dated December 21, 2012 with OJSC “CC MPFG “Formash”).

– Contract with SE “Belarusian Railway” No. I-48/2015/59-P/Y-332 dated 05/18/2015.

#### Field of Application

The pads are intended for the use at lines with mixed traffic, including heavy traffic, as well as on express and high-speed lines. By agreement with the consumer, pads for the required type of the rail fastening can be made from EKM-D material.

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## ULTRA-IMPACT-RESISTANT COMPOSITE MATERIALS “ETAMIDE” BASED ON BLENDS OF POLYAMIDE 6 WITH SPECIALLY FUNCTIONALIZED POLYMERS AND COPOLYMERS OF POLYOLEFINS FOR FLEXIBLE PIPES, HOSES AND BLOW PRODUCTS



Gasoline vapor separator made  
of polyamide composite “Etamide EA-EU (V)”  
(TCBY40084698.267-2014).  
JSC Avtovaz (Tolyatti, Russian Federation)  
produced more than 50,000 separators



Flexible pipes for tractor “Belarus” air brake  
systems made of polyamide composite  
“Etamid EA-2EU (T)” (TU VU40084698.267-2014).  
More than 100 km of pipes were produced

### Development Description

Scientific principles and a set of recipe and technological solutions for the production of polyamide composite materials of the “Etamide” type, including ultra-high-impact composites with high and controllable viscosity, as well as melt strength, suitable, unlike the original low-viscosity domestic polyamides, for processing by methods continuous extrusion and blown extrusion. The development is based on the discovered and scientifically substantiated effect of an anomalous increase (by more than two orders of magnitude) in the melt viscosity of mixtures of aliphatic polyamides with specially functionalized polymers and olefin copolymers. Using Etamid materials, the technology of import-substituting flexible polyamide pipes for pneumatic systems of serial models of Belarus tractors and gasoline vapor separators of “Lada” cars was developed at Avtovaz OJSC (Tolyatti, Russian Federation).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Composite materials of the “Etamide” type have 1.8 times higher impact resistance, including at low temperatures, and improved deformation-strength and technological characteristics compared to similar materials

(France). Etamide composite materials are processed using blowing and continuous extrusion technologies that are unconventional for polyamide 6.

#### Intellectual Property Protection

- Blended polyamide composite: patent. BY 21137 / S. S. Pesetskii, Yu. M. Krivoguz. – Publ. June 30, 2017;
- Blended impact-resistant composite: Pat. BY 22763 / S. S. Pesetskii, Yu. M. Krivoguz. – Publ. December 30, 2019.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

- SRP “Physical Materials Science, New Materials and Technologies”, 2016–2020; tasks 6.08 “Development of methods for the functionalization of polyolefins in the melt in the presence of coagents, as well as using new technological techniques to control the selectivity of grafting and the course of side reactions” and 6.54 “Research of the process functionalization of mixtures of polyolefins and copolymers of ethylene with higher olefins and development of the fundamentals of technology for functionalized products for various purposes”;
- BRFFR project T18 AZ-001 “Functionalization in the process of reaction extrusion of polybutene, its mixtures with polypropylene and copolymers of ethylene with octene and hexene”, 2018–2019;
- Scientific and Technical Program of the Union State “Development of innovative technologies and equipment for the production of competitive composite materials, matrices and reinforcing elements for 2012–2016” (code “Kompomat”), task 2 “Development of technology for the production of thermoplastic composites for technical and household purposes and competitive polymer matrices based on saturated polyesters, polymers and olefin copolymers”;
- License contract with the Institute of Energy of the Shandong Academy of Sciences (China) “Obtaining the right to use undisclosed information regarding the technology of impact strength modifiers and impact-resistant polyamide composites” 2014–2024.

#### Field of Application

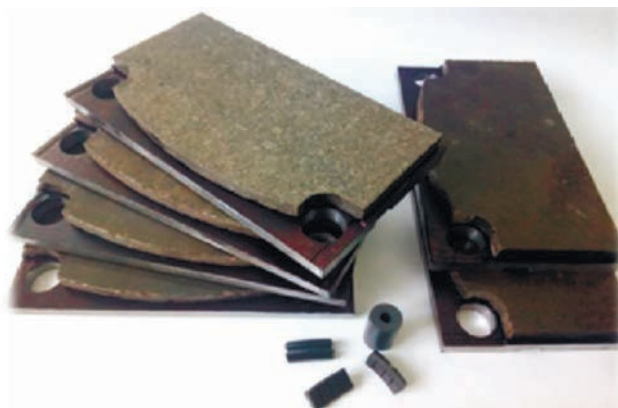
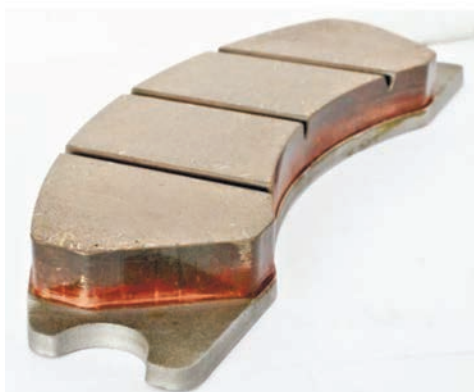
Flexible pipes and hoses, fuel-resistant pipelines, containers for storing and transporting fuels and oils, fire-resistant corrugated pipes.

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State Scientific Institution “V. A. Belyi Metal-Polymer Research Institute  
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## LOW-NOISE NAO FRICTION MATERIALS FOR FRICTION UNITS OF TRANSPORT AND TECHNOLOGICAL MACHINES



### Development Description

Noise reduction, including in such sources as friction units of transport and technological machines, special equipment, and various technical equipment is necessary to increase their competitiveness, reliability, and meet international environmental and health safety requirements for noise. Along with the design, materials play a key role in reducing the intensity of acoustic emission during friction. NAO friction composites (Non Asbestos Organic), which do not contain carcinogenic and metal fillers, are used for the manufacture of brake linings, friction discs, and other parts of the most critical and technological components of machines – brakes, transmissions and stationary friction devices.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed NAO friction composites have no analogues in the CIS countries. The technical characteristics of the composites correspond to the best foreign analogues. Some brands of composites are certified in accordance with international standards and have received approval from the world's leading equipment manufacturers: “JSC Tupolev” (Russian Federation), “Drillmec” (Italy) and others. The developed composites have static-kinetic friction characteristics that minimize frictional self-oscillations

and, thus, noise generated during friction, provide a specified and stable coefficient of friction, high wear resistance and frictional heat resistance, and can be used in arctic conditions.

#### Intellectual Property Protection

The application for the invention “Friction composite material” is under examination at the National Center for Intellectual Property. State registration number of application No. a 20230308 dated 12.04.2023.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

– SRP “Materials Science, New Materials and Technologies”, 2021–2025, subprogram “Multifunctional and Composite Materials”, task 4.2.3. Research work 3 “Study of noise generation mechanisms in tribocouplings and improvement of polymer friction composites with low noise emissions for high-temperature friction units of energy-saturated machines and equipment”;

– SRP “Physical materials science, new materials and technologies”, 2016–2020, subprogram “Polymer materials and technologies”, task 6.44 “Development of methods for producing composite materials for tribotechnical purposes with improved static-kinetic characteristics for brake units of machines”;

– Project of the Belarusian Republican Foundation for Basic Research T21ET-015 “Development and research of friction materials with low corrosion and noise activity for friction brakes of electric vehicles” (2021–2023).

#### Field of Application

Mechanical engineering, transport and communications, energy.

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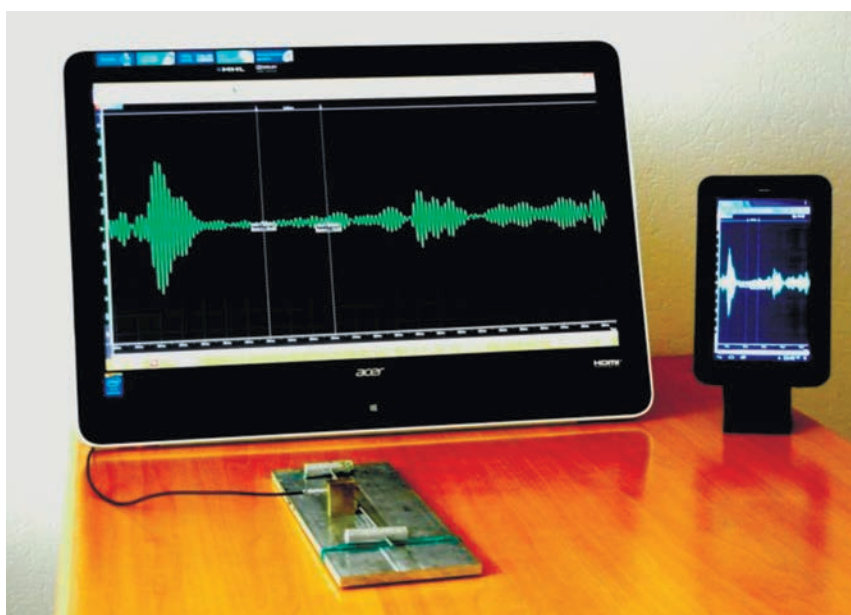
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## EQUIPMENT SET FOR CONTROL OF FRICTION STIR WELDING



### Development Description

The technology of non-destructive quality control of welded joints made by friction stir welding, with the equipment and software that implement it is intended for expert ultrasonic testing of full-scale longitudinal and circumferential welds of launch vehicle fuel tanks produced by friction stir welding. The equipment makes it possible to identify defects typical for these objects, such as lack of penetration at the root of the weld, adhesion, etc. The ability to implement various schemes for monitoring welded joints of sheet materials (monitoring with inclined transducers in a separately combined mode at the intersection of emitter and receiver radiation patterns, monitoring the root zone of the weld from the outer surface with surface wave transducers, etc.) allows you to optimize the inspection process in order to ensure the specified sensitivity and resolution abilities depending on the geometry of the product and the internal structure of the metal in the weld zone. For welded joints produced by friction stir welding the developed equipment provides detection of defects with an opening of 2 microns or more.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Identification of characteristic defects (non-cord in the root of the weld, cracks, oxide captures) of welded joints from aluminum magnesium alloys: disclosure of detected defects is 2  $\mu\text{m}$  or less; the height of the identified defects is 200 microns or less; resolution on the front is better than 200 microns; identification of oxide films in the root of the seam within the overall sensitivity. The equipment has no analogues in the Republic of Belarus; in terms of its technical and operational characteristics, it corresponds to the level of the CIS countries.

#### Intellectual Property Protection

Piezoelectric transducer for ultrasonic testing of friction stir welding (utility model); Patent of the Republic of Belarus No. 11897 for a utility model.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Program of the Union State “Development of integrated technologies for creating materials, devices, and key elements of space vehicles and promising products of other industries” (“Technology-US”, 2016–2020), task 1.2.3.1 “Develop a technology for non-destructive quality control of welded joints made by friction stir welding”.

#### Field of Application

The equipment can be used when inspecting products containing welded joints, including those made by friction stir welding. Potential consumers are aerospace industry enterprises, including Roscosmos Concern, mechanical engineering and instrument making enterprises.

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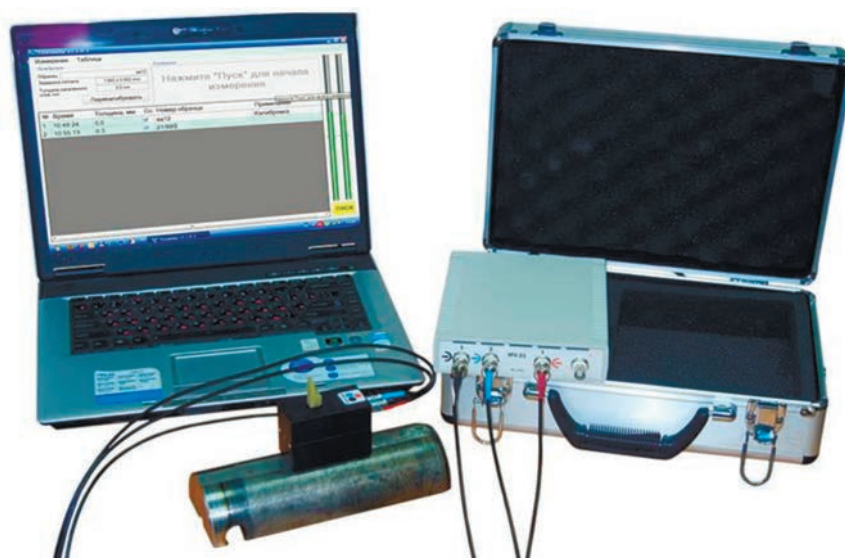
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State Scientific Institution "Institute of Applied Physics  
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## EQUIPMENT SET FOR CONTROL OF THE DEPTH OF STRENGTHENED LAYERS



### Development Description

The equipment set is designed to control the thickness of the hardened layer (laser hardening, hardening after carburization, high-frequency hardening) using a non-destructive ultrasonic method based on the analysis of changes in the elastic properties of the material as a result of heat treatment. The range of measured thicknesses of the hardened layer is 0–6.0 mm, measurement accuracy is within  $\pm 15\%$ . The equipment set consists of an electronic unit, a set of specialized converters and software based on OS Windows. The control is carried out via a personal computer, measurement results are saved in the form of Excel tables. Measurements can be carried out both on a flat surface of a part and on a cylindrical one (along its generatrix), and using special transducers on a cylindrical surface (across the generatrix) and on complexly configured surfaces (fillet transitions, surfaces of gear teeth, etc.).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The possibility of measuring on products with various surface shape (tough transitions, surfaces of teeth of gears, etc.). The equipment has no

analogues in the Republic of Belarus; in terms of its technical and operational characteristics, it corresponds to the level of the CIS countries.

#### Intellectual Property Protection

Method for ultrasonic testing of the depth of the hardened layer of a part made of steel (invention). Patent of the Republic of Belarus No. 23417.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Mechanics, metallurgy, diagnostics in mechanical engineering”, 2016–2020; subprogram “Technical diagnostics”; task 3.06 “Development of physical foundations and design of combined methods and means for acoustic and optical diagnostics of materials with inhomogeneous and layered structure”; contract No. 9/1116 “Manufacturing and supply of a set of equipment for indicating the depth of a layer hardened by laser thermal hardening technology”, 16.11.2016 – 31.01.2017.

#### Field of Application

The equipment is intended for measuring the depth of hardened layers on steel products at mechanical engineering, energy, and transport enterprises.

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## MAGNETIC MEASURING UNIT



### Development Description

Magnetic measuring unit (hereinafter referred to as the “unit”) is designed to reproduce and transmit to standard samples made of soft magnetic materials the size of units of specific magnetic loss and magnetic induction in the frequency range from 50 Hz to 200 kHz. The unit is a complex of measuring instruments and auxiliary devices combined in software (and in the instrument rack) to solve measuring tasks. The installation allows

measurements on Epstein samples, whole sheets, as well as ring samples. The operation of the installation is based on the induction method, which allows you to measure directly electrical quantities and calculate the magnetic characteristics of materials from them. The method is based on analogue-to-digital conversion of instantaneous values of signals proportional to the magnetic field intensity on the surface of the standard sample and the time derivative of the average magnetic induction along the sample cross-section into digital codes with subsequent calculation of magnetic characteristics of the sample.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Functionally, the installation allows: measurement of specific magnetic losses in the range from 0.3 to 100.0 W/kg with an error of  $\pm 0.8 \%$ ; up to  $\pm 3.0 \%$ ; measuring the amplitude of magnetic induction in the range from 0.1 to 2.0 T with an error of up to  $\pm 0.6 \%$ ; construction of dynamic magnetic hysteresis loops and the main magnetization curve; Digital path calibration saving measurement results. Accuracy indicators and functionality are at the level of the world's best analogues (Japan, RF, China).

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Contract No. 4/3-23 dated 06.07.2023 "Development of a Sample Magnetic Measurement Unit" (customer – Laboratory Solutions LLC, Russian Federation).

**Field of Application**

The highest level of the verification scheme in the metrology of magnetic characteristics, scientific research in the field of magnetic characteristics of soft magnetic materials and algorithms for the interaction of energy sources and magnetic circuits, high-precision industrial control of magnetically soft materials properties.

**Contact Information of Organization-Developer**

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State Scientific Institution "Institute of Technical Acoustics  
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## LAYERED STRUCTURE MATERIAL WITH HIGH MAGNETOELECTRIC PROPERTIES

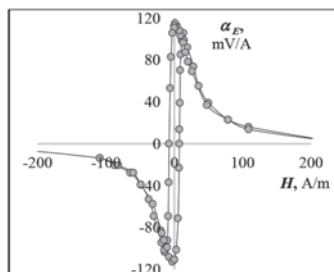


Figure 1. Field dependence of the linear ME coefficient of the three-layer symmetric structure Ni-piezoceramic BaTiO<sub>3</sub>-Ni

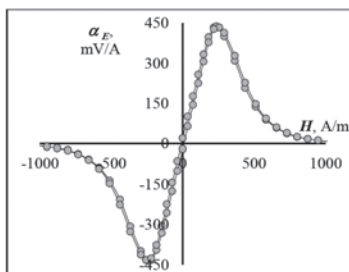


Figure 2. Magnetolectric properties of metal-piezopolymer-metal structures obtained by electrochemical deposition

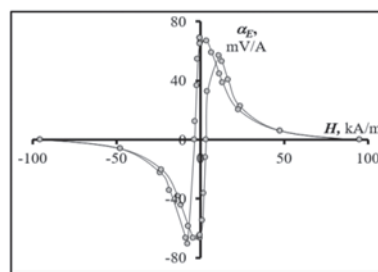


Figure 3. Linear magnetolectric effect in a metal-ferroelectric-metal hybrid structure based on PZT-nickel ferrite with nickel and cobalt coatings

### Development Description

For the first time, polymer-based flexible structures having ME coefficient of more than 100 mV/A, have been obtained by electrochemical deposition. The studies show the possibility to fabricate hybrid structures based on bulk ME composites providing an increase in the ME coefficient, a shift in the maximum value of the ME coefficient to the area of low magnetic fields increasing ME sensitivity. It was found that the occurrence of electrical response in magnetoelectric structures at a zero magnetic field was possible due to the combination of positive and negative magnetostriction materials. The fabrication of hybrid structures based on lead-free ceramics allows the values of the ME effect to be achieved comparable to the effect of layered and bulk lead-containing structures.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

For the first time, flexible Ni/PVDF/Ni structures based on PVDF-TrFe (70:30 %) having the ME coefficient of more than 100 mV/A, have been obtained by electrochemical deposition. The obtaining of ME structures based on piezopolymers has become one of the most promising areas of research of functional multiferroics that have broad application prospects in smart devices as functional biocompatible materials. For the first time hybrid structures were fabricated. The obtained values of the ME coefficient

in the low frequency area of 110 and 437 mV/(cmOe) are the maximum values for lead-free flexible polymer/ceramic based composites, respectively (Fig. 1 and 2). Magnetoelectric composites generating an electrical response at zero magnetic field due to the combination of positive and negative magnetostriction materials were obtained for the first time in the world (Fig. 3).

#### Intellectual Property Protection

Patent of the Russian Federation No.2739161

Name of the programme, subprogramme, project, business contracts under which the development was obtained

- State Research Program “Materials Science, New Materials, and Technologies”; subprogramme “Electromagnetic, beam-plasma, and casting deformation technologies for processing and obtaining materials”, complex task “Development of high-energy technological processes for obtaining and processing functional and smart materials”, research “Development of effective methods for high-energy exposure for obtaining and processing of modern functional and smart materials” (2021–2025);
- BRFFR-MCTF, grant F20MC-006 “Adjustment of the magnetoelectric response by modifying the chemical composition of composite multiferroics of complex structure” (2020–2022);
- BRFFR-VAST, grant F21BA-006 “Electromagnetic correlations in some lead-free piezoelectric materials and multiferroic composites with magnetoelectric effect” (2021–2023).

#### Field of Application

Composite materials for radio electronics; combined devices, installations for measuring electrical and magnetic values; medical complexes, systems, instruments, apparatuses and devices for combined therapeutic and diagnostic purposes.

#### Contact Information of Organization-Developer

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State Scientific Institution "Institute of Technology of Metal  
of the National Academy of Sciences of Belarus"

## WEAR-RESISTANT CHROMIUM IRON FOR CASTING CONSUMABLE PARTS OF CENTRIFUGAL CRUSHING AND GRINDING EQUIPMENT



### Development Description

The dependences of wear, strength, hardness, and microhardness of wear-resistant cast iron on the content of alloying elements and its heat treatment methods have been established. The composition of cast iron ICHH18G2VM has been developed, additionally containing molybdenum, vanadium and tungsten. A special hypereutectic high-chromium cast iron alloyed with niobium has also been developed.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed cast iron compositions for casting consumable parts of centrifugal crushers make it possible to increase their wear resistance in comparison with analogues available on the markets of the Republic of Belarus and the Russian Federation by 10–25 % and reach the level of the best foreign analogues. The casting technology ensures the production of a finely dispersed structure of chromium cast iron. The resulting parts are characterized by a long service life. The operating time of such parts is

1.5–2 times longer than that of existing analogues. The use of alloyed steel scrap reduces the cost of products by 10–15 %.

#### Intellectual Property Protection

Patent BY 23010 C1 Republic of Belarus, IPC C 22C 37/08/Wear-resistant cast iron; application 05.11.2018.

Name of the programme, subprogramme, project, business contracts under which the development was obtained

SRP “Physical Materials Science, New Materials, and Technologies”, 2016–2020, subprogram “Materials in Engineering”, task 3.1.09 “Study of the complex influence of alloying and heat treatment on the structure and operational properties of chromium cast irons with increased wear resistance” and task 3.1.05 “Study of the complex effect of alloying elements and modifying components on carbide formation in cast irons and the development of compositions of wear-resistant alloys with dispersed carbides”.

#### Field of Application

Mining, construction and glass industries.

#### Contact Information of Organization-Developer

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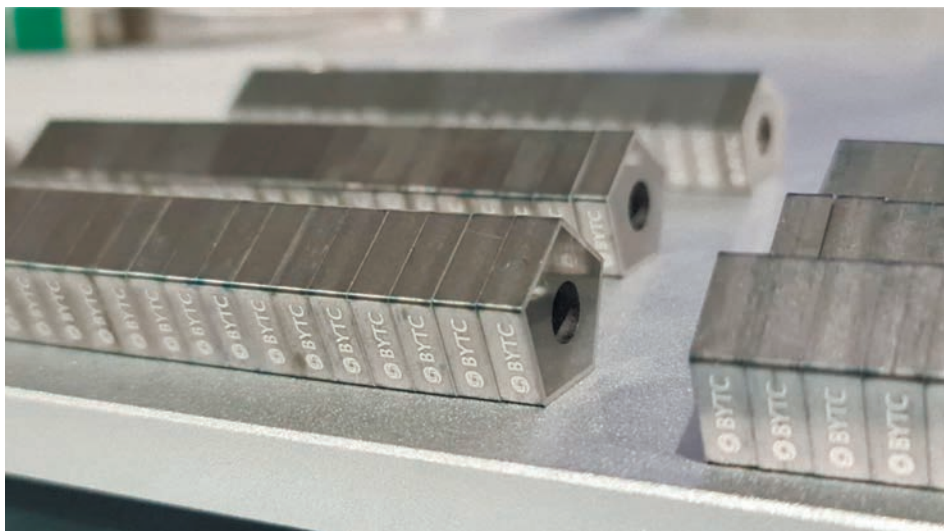
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State Scientific Institution "Institute of Technology of Metal  
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## ESTABLISHMENT OF PRODUCTION FOR HIGH-QUALITY CUTTING TOOLS UNDER "BYTC" BRAND (BELARUSIAN HARDENED CARBIDE)



### Development Description

The current domestic and international experience in the production of replaceable multi-edged inserts has been synthesized. A section for pressing and sintering carbide products has been established, equipped with the most advanced technological equipment, incorporating numerous innovative enhancements at each technological stage. Technological processes for the production of carbide products of grade YT5 ( $\text{TiC} - 5\%$ ) have been developed. The manufactured BYTC carbide inserts undergo multi-stage inspection according to six methodologies: density and mass determination, chemical composition, hardness, geometric dimensions, porosity, and grain size. Consequently, the innovative technology for producing BYTC carbide inserts developed at the IMT of the NAS of Belarus enables the production of high-quality metal-cutting carbide inserts.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Scientific and technical level (relative to the best domestic and foreign counterparts): innovative production technologies for carbide inserts,

adapted to contemporary and unique equipment, allow for the simultaneous debinding and sintering cycle, thereby reducing sintering time by 1.5–2 times and simplifying the production process. The high quality of the metal-cutting tools obtained from the powder mixture is ensured by strengthening through aerodynamic acoustic resonance impact. This impact can reduce the dislocation density of carbide components by 15–20 % and increase the plasticity of the cobalt binder, thereby reducing the number of structural pores, increasing tool life by up to 2.5 times, and enhancing impact toughness by 19–23 %, while maintaining high hardness (up to HRA 92). As a result, the wear resistance of BYTC inserts, manufactured using technologies developed at the IMT of the NAS of Belarus, is 1.3–1.4 times higher in relation to the foreign analogues.

#### Intellectual Property Protection

- Application No. 20230953 dated May 15, 2023 for registration of the trademark “BYTC”;
- Patent BY 21049 CI Republic of Belarus, IPC C 21D 8/00/Method of aerodynamic hardening of products;
- Patent RU 2 557 175 C2 Russia, IPC C21D 8/00, C21D 9/22 / Method of aerodynamic hardening of products; application 10/29/2013.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Mechanics, metallurgy, diagnostics in mechanical engineering”, 2021–2025, subprogram “Metallurgy”, task 2.18 “Study of structural changes in carbide tools obtained by metallurgical methods and strengthened by the aerodynamic sonic method, intended for processing discontinuous surfaces of cast iron parts”.

#### Field of Application

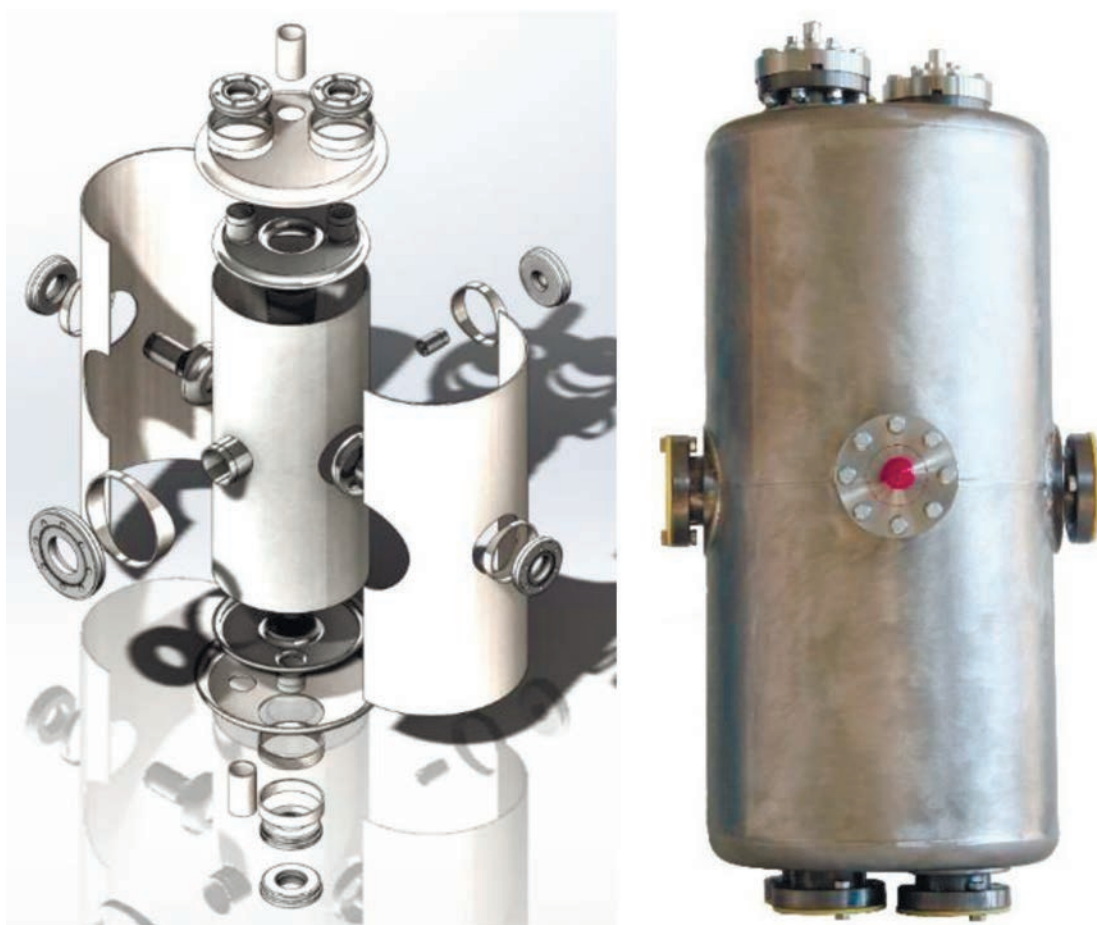
Metalworking industry.

#### Contact Information of Organization-Developer

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State Scientific Institution “Physical-Technical Institute  
of the National Academy of Sciences of Belarus”

## SUPERCONDUCTING HALF-WAVE RESONATORS MADE OF EXTREMELY PURE NIOBIUM



### Development Description

The resonators were made using technologies for forming individual elements and their electron beam welding (EBW). The development included computer modeling of the superconducting niobium half-wave resonator (HWR) design in cooperation with MEPhI (Moscow, Russian Federation) and technological tooling for forming individual elements of the resonator and their EBW. Sequential connections of elements made of extremely pure niobium inner and outer electrodes with antenna and power input spigots, span channel cups with drift spigots, end caps with flushing spigots and HWR internals with flanges made of NbTi, titanium VT1-0 housing



with HWR internals were performed. At all stages of work the samples were washed, chemically polished before EBW, and finish washing of niobium HWR resonators was carried out.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Parameters of resonators correspond to the best foreign analogs, requirements for operating frequency and quality factor  $Q = 3.5 \times 10^8$  (there are no domestic analogues). The obtained results will allow participating together with the organizations working in this field in international projects on manufacturing and delivery of superconducting niobium resonators, as well as in research and development in the field of particle accelerators for research and applied purposes.

**Intellectual Property Protection**

Patents of the Republic of Belarus:

- Method for manufacturing a half-cell resonator of a charged particle accelerator.
- Welded connection of half-cells of a volumetric resonator.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Within the framework of international project No. 02-1065-2007/2023 “NICA Complex: Creation of a Complex of Accelerators, Collider and Experimental Facilities on Counter and Departed Ion Beams for the Study of Dense Baryonic Matter, Spin Structure of Nucleons and Light Nuclei, Applied and Innovative Works” for the proton modular linear accelerator-injector (Superconducting Linac) under construction at the Joint Institute for Nuclear Research (Dubna, Russian Federation) (2017–2023).

**Field of Application**

Modern mega-science particle accelerators complexes.

**Contact Information of Organization-Developer**

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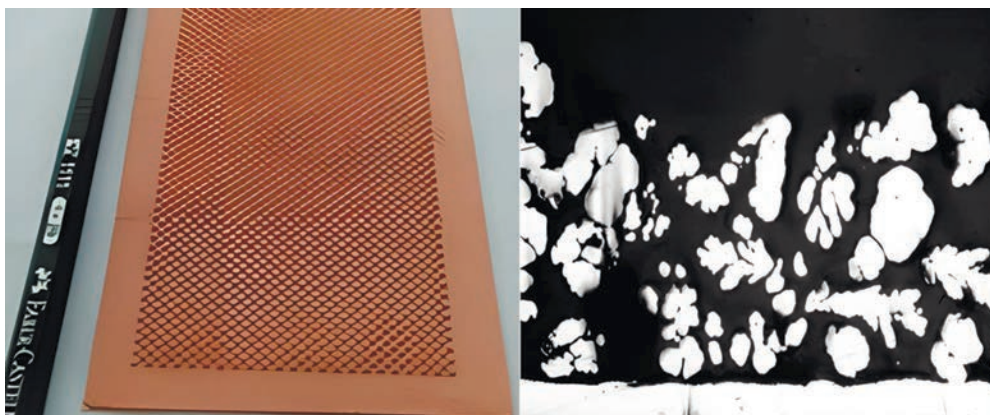
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The State Scientific Institution “O. V. Roman Powder Metallurgy Institute”

## SUBMILLIMETER-THICK VAPOR CHAMBER WITH POWDER CAPILLARY STRUCTURE



Design and pore structure of a miniature capillary chamber with metal powders

### Development Description

The miniature capillary chamber with metal powders provides temperature mode stability for the miniature heat generating elements of modern electronics.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The development ensures the increase of energy load and miniaturisation of components of computers and smart phones of a new generation with the use of thin (0.3–0.4 mm) flat heat pipes vapour chambers, whose main functional element is a flat powder capillary structure with a thickness of about 0.1 mm.

Specifications:

- dimensions: 100 × 60 × 0.4 mm;
- heat generation area dimensions: 10 × 10 mm;
- heat dissipation capacity: 6 W;
- maximum temperature difference: 6 °C.

Advantages: higher heat transport characteristics, the thickness is less than that of known analogues. The level of development is “world-class”.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained:**

State Research Program “Materials science, new materials and technologies”, 2021–2025; subprogram “Multifunctional and composite materials”; project 4 “Development of the design and manufacturing of composite powder hydraulic valves for anti-gravity heat pipes method”; 4.1.2 “Development and research of materials for capillary transport”.

**Field of Application**

Production of new generation computer and smart phone components using thin (0.3–0.4 mm) flat heat pipes (vapour chambers).

**Contact Information of Organization-Developer**

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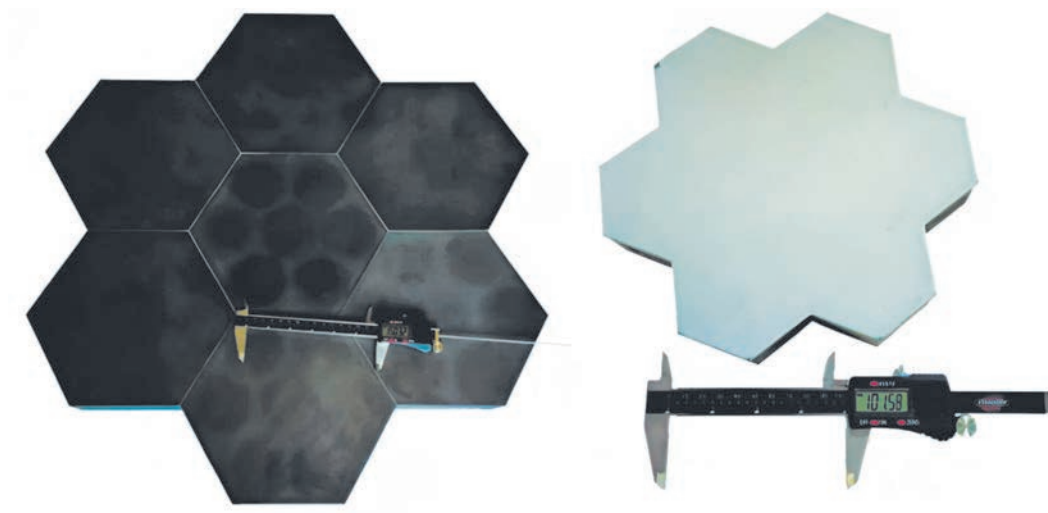
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The State Scientific Institution “O. V. Roman Powder Metallurgy Institute”

## PREFABRICATED MIRROR SUBSTRATE MADE OF SILICON CARBIDE



### Development Description

The lightweight prefabricated mirror substrate is produced using the developed technology by reaction soldering optical glass onto a silicon carbide substrate.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Specifications:

- density of SiC ceramics: 2.9–3.1 g/cm<sup>3</sup>;
- carbide phase microhardness: 22–28 GPa;
- bending strength of SiC ceramics: 250–350 MPa;
- Young’s modulus of SiC ceramics: 375–385 GPa.

Operating conditions of glass-coated SiC ceramics:

- operating temperature:  $(20 \pm 10) ^\circ\text{C}$ ;
- pressure of gas medium: 10–3 Pa;
- temperature range:  $(-30...+50) ^\circ\text{C}$ .

**Advantages:** Due to the low density and high specific stiffness of silicon carbide ceramics, it is possible to produce large optical mirrors of lightweight design. The novelty of the technology developed lies in the creation of reaction soldering modes for optical glass onto a lightweight silicon carbide substrate. The level of development is “world class”.

**Intellectual Property Protection**

Patents of the Republic of Belarus: No. 21557, 23570, 20898; Patent of the Russian Federation for the utility model No. 2591209.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of integrated technologies for creating materials, devices, and key elements of space vehicles and promising products of other industries” (“Technology-US”, 2016–2020); task 1.1.4.1 “Develop a technology for producing high-density reaction-baked silicon carbide ceramics for use in optoelectronic devices for aerospace purposes”.

**Field of Application**

Plates made of silicon carbide ceramics coated with optical glass are intended for manufacturing mirror-lens systems, including the production of optical telescope mirrors.

**Contact Information of Organization-Developer**

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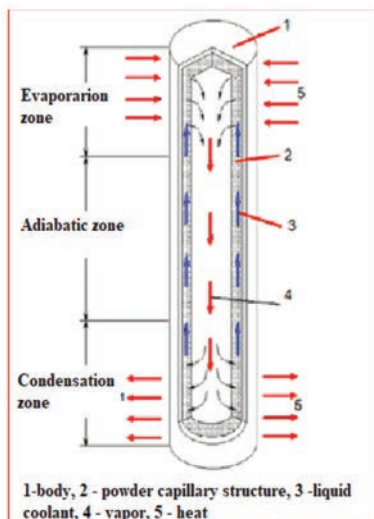
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The State Scientific Institution "O. V. Roman Powder Metallurgy Institute"

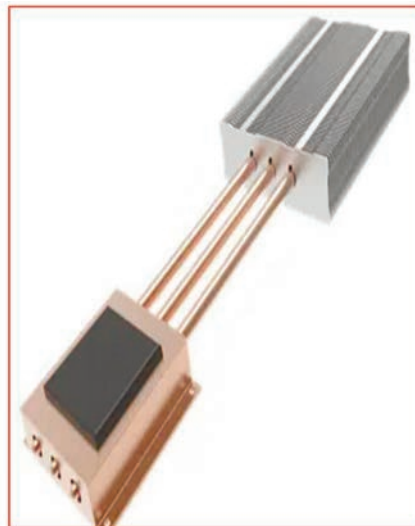
## ANTIGRAVITY HEAT PIPE (AGHP)



Work of AGHP



Heterogeneous powder composite material (CM)



Cooling of an electronic element by a heat sink based on AGHP



Antigravity heat pipes

### Development Description

At present time, heat pipes (HT) are hermetically sealed heat transfer devices, which common feature is functioning according to the principle of a closed evaporation-condensation cycle are effectively used as basic elements of temperature control systems for heat generating devices. The rapid technology development, primarily electronic and electrical engineering, is associated with a significant increase in the heat flows density, which poses new design and technological challenges to the cooling systems developers. The necessity to develop CTs with considerably higher heat transfer characteristics arises in comparison with CTs produced in our country and abroad. The most promising way to solve this problem is to increase the efficiency of applied powder capillary structures (CS),

in particular, to increase the capillary-transport ability of the last by creating powder distribution inhomogeneity along the CS axis. The development corresponds to the priority direction of scientific, scientific-technical and innovation activity in Belarus for 2021–2025, defined by the Decree of the President of the Republic of Belarus dated 07.05.2020 № 156:4. Mechanical engineering and innovative materials – composite and multifunctional materials. The project implementation is directly related to further information development, machine-building technologies and energy.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Thanks to the creation of a multilayer powder CS with optimal pore distribution, the heat transfer capacity of the developed anti-gravity heat exchanger is 2.5–3 times higher than the heat transfer capacity of a traditionally designed heat exchanger. The development is export-oriented.

**Intellectual Property Protection**

- Russian Federation patent for utility model No. 220328 “Flat heat pipe”. Date of registration 07.09.23;
- Patent of the Republic of Belarus for utility model No. 13262 “Flat heat pipe”. Date of registration is 30.08.23.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Innovative Materials and Technologies”, 2021–2025, “New materials on metal, ceramic, polymer bases, superhard materials and technologies for their production” section, project 2.106 “Develop design and technology for obtaining multilayer powder capillary structure of antigravity heat pipes for efficient cooling of modern electrical engineering and radio electronics and to organize antigravity heat pipes pilot production” (2023–2024). Commercial agreement № 333-24 dated 24.06.2022 with “Bel Hua-wei Technologies” LLC, 2022–2023.

**Field of Application**

The development is in demand at manufacturing enterprises of electronic and electrotechnical industry.

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**Republic Scientific and Industrial Unitary Enterprise  
“Institute of Power Engineering  
of the National Academy of Sciences of Belarus”**

## **COMPLEX OF EQUIPMENT FOR RECYCLING ORGANIC WASTE USING RECEIVED THERMAL ENERGY**



### **Development Description**

The experimental sample of the equipment complex was developed and manufactured. It is intended to carry out R&D work on the development of cost-effective waste disposal technology. This complex is capable of using a wide range of wastes in any physical form (solid, liquid, gaseous) as samples for scientific research. The experimental sample of the equipment complex is built on a modular principle, which makes it possible to study the processes of obtaining flammable gaseous products from waste as a result of thermal decomposition, decomposition under the influence of a high-frequency electromagnetic field or as a result of their combined effects. The design of the experimental sample of the equipment complex will allow performing experimental studies in automatic and manual modes, which is fundamentally important for scientific research equipment. This feature allows studying in detail both individual stages and the overall process of obtaining thermal energy from waste. The experimental sample

of the equipment complex is capable of providing heating and hot water supply to industrial premises in a pilot mode. The production of the experimental model of the equipment complex for organic waste recycling using the generated thermal energy has been mastered.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The research results obtained clearly indicate that the use of a high-frequency magnetic field to obtain thermal energy from waste is completely justified. The waste pyrolysis time is reduced by almost 40 %, which increases equipment productivity. The temperature in the high-temperature post-combustion chamber increases by 15 % contributing to more efficient waste disposal and increasing the efficiency of the equipment when generating thermal energy. There are no analogues in the world.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Contract with the National Academy of Sciences of Belarus No. 201726089 dated December 8, 2017 for carrying out research, development, and experimental technological work “Development, manufacture and implementation of a set of equipment for the disposal of organic waste using the generated thermal energy.”

**Field of Application**

Waste recycling with heat production for enterprises in all sectors of the economy.

**Contact Information of Organization-Developer**

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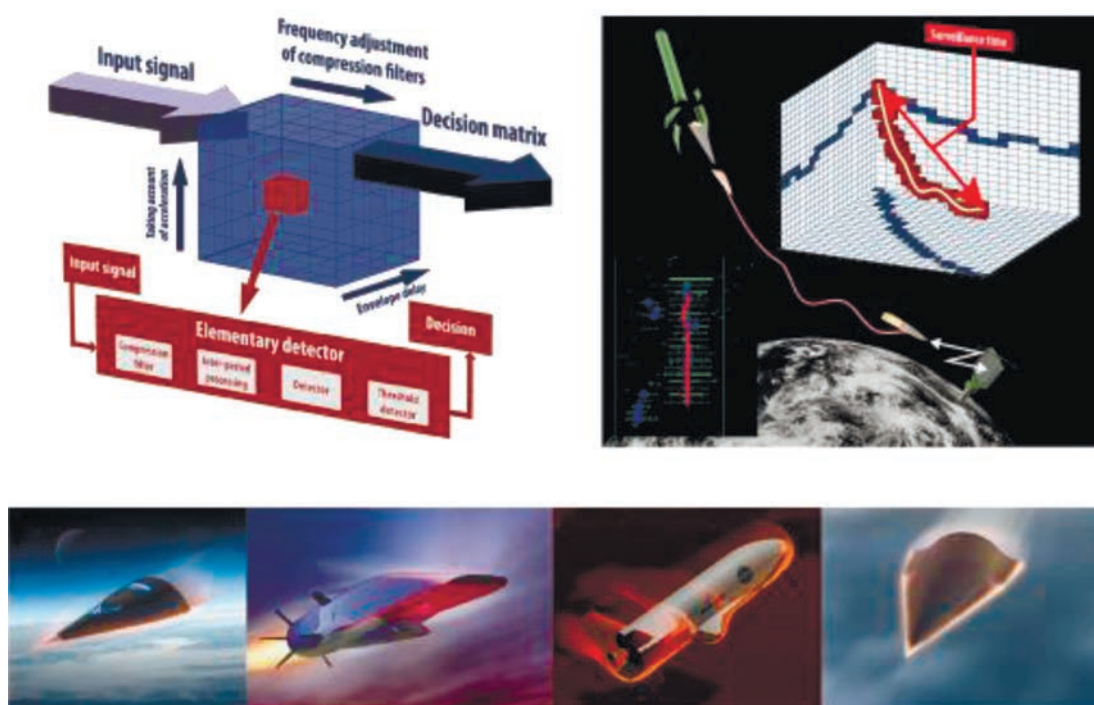
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**Republican Science and Production Unitary Enterprise  
“Center of Radio Engineering of the National Academy of Sciences  
of Belarus”**

## **METHODS, TECHNIQUES, AND ALGORITHMS FOR TECHNICAL IMPLEMENTATION OF RADAR DETECTION AND TRACKING OF HYPERSONIC AIRCRAFT VEHICLES**



### **Development Description**

Options for the technical implementation of a radar for detecting hypersonic aircrafts (HSAV) are offered. HSAV includes devices that have a flight speed of 5–10 M (6150–12,300 km/h) and higher, with an operating altitude range from 20 to 100 km.

The impossibility of detecting such objects for military purposes by traditional methods used in modern radar stations is due to:

- hypersonic flight speed and extremely high maneuverability characteristics of the hypersonic aircraft, which exclude the possibility of radar observation of these objects using traditional methods for working against conventional air targets;

- presence of a dynamically changing plasma shell around HSAV providing absorption or re-reflection of electromagnetic energy;
- very low RCS of HSAV which makes these objects into “stealth targets”.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no analogues: at present, domestic and foreign modern radar technology is not capable of detecting HSAV. Advantages of our development:

- theoretical and practical laws of signal extraction against the background of interference have been expanded for HSAV presence in several resolution elements by angular coordinates, range, and radial velocity during a single contact with the target;
- methods, techniques, and algorithms for long-term accumulation of the signal reflected by a maneuvering HSAV in the presence of artificial and natural interference and a compromise distribution of observation time between coherent and incoherent accumulation were obtained;
- algorithms for detecting and tracking of high-speed maneuverable objects have been developed and a study of their effectiveness has been carried out.

**Intellectual Property Protection**

The development results constitute a trade secret.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Research and development work “Development of technology for detecting space objects in near space using ground-based radar”. It was carried out under a contract in the interests of a foreign customer.

**Field of Application**

The results of the development can be used in multifunctional radars that detect and track high-speed maneuverable objects in near space.

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The figure illustrates the radar target recognition architecture and the corresponding range-Doppler spectrum.

**Architecture:** The radar system receives a signal and sends it to the Interfacing module. The Interfacing module also receives sync signals and information from exchange channels. The Interfacing module outputs to the Profile extraction module and the Signature processing device. The Signature processing device outputs to the Target type decision block. The Profile extraction module also outputs to the Signature processing device.

**Range-Doppler Spectrum:** The plot shows the magnitude of the range-Doppler spectrum  $|g(f)|$  versus frequency  $f$ . The spectrum is divided into three main regions: Lower side band ( $k < 0$ ), Air frame (fuselage) ( $k = 0$ ), and Upper side band ( $k > 0$ ). The Air frame region is further divided into  $k = -N_1$  and  $k = N_1$ . The spectrum shows a central peak at  $f_0 + F_{dc}$  and sidebands at  $f_0 + F_{dc} + kF_b$ . The range resolution is  $\Delta R_c$  and the Doppler resolution is  $\Delta F_c$ . The range resolution is  $\Delta R_c = \frac{c}{2B}$  and the Doppler resolution is  $\Delta F_c = \frac{1}{T}$ . The range resolution is  $\Delta R_c = \frac{c}{2B}$  and the Doppler resolution is  $\Delta F_c = \frac{1}{T}$ .

The system of non-cooperative radar recognition of aircraft types for non-board pulse-Doppler radar is designed to automatically determine the types of jet and propeller-driven aircraft tracked by a non-board radar as a result of a detailed analysis of the “delicate” properties of radar signals reflected from these objects and radar information received by the radar. The recognition of aircraft types using pulse-Doppler radar is an urgent task. Despite the large number of scientific publications on radar recognition, in practice the task of recognition of aircraft types, as opposed to recognition of their classes, which combine different types, for example, F-15, F-16, B-52, B-2, etc., has not yet been resolved. As a result of the study and analysis of various radar features of radar recognition of classes and types

of air objects, a theory of radar recognition of aircraft types, algorithms for the operation of a system for automatic recognition of types of jet and propeller aircraft, and software confirming the effectiveness of the developed algorithms were developed. Research has been carried out on the performance indicators of the aircraft type recognition system under various conditions of its use. Effective solutions have been obtained to eliminate the influence of the engine operating mode of a maneuvering aircraft on the recognition results.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no domestic analogues of the system of non-cooperative radar recognition of aircraft types for the on-board pulse-Doppler radar. Compared to foreign analogues, this development provides a significantly higher reliability of aircraft type recognition. For example, recognition of 10 types of jet aircraft with a signal-to-noise ratio at the input of the recognition system of at least 15 decibels is performed with an average probability of true type recognition of at least 0.71.

**Intellectual Property Protection**

The development results constitute a trade secret.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Research and development work “Development of an automatic target recognition system for pulse-Doppler airborne radar”. It was carried out under a contract in the interests of a foreign customer.

**Field of Application**

The results of the development can be implemented in on-board radars of aeroplanes and helicopters to effectively solve problems of non-cooperative recognition of types of air objects.

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**Republican Unitary Enterprise “Research and Production Center  
for Multifunctional Unmanned Complexes”**

**UNMANNED AERIAL SYSTEM “BUREVESTNIK”**



**Development Description**

THE long-range unmanned aerial system “Burevestnik” is designed for video and radiation monitoring of the area, detecting objects and determining their coordinates, tracking moving objects from board of an unmanned aerial vehicle, and transmitting the received information via radio channel to a ground control station and other remote consumers in real time. The operating range of two-channel data receiving and transmitting equipment under direct radio visibility is up to 150 km. If there is one remote terminal of the ground transceiver system, the monitoring radius can be increased to 400 km. The maximum ferry range (take-off from one airfield, landing at another airfield) is up to 1000 km. The unmanned aerial system includes “Burevestnik” unmanned aerial vehicle (UAV); ground control station (GCS) with modern digital communication channels for controlling the launch and flight of the UAV, receiving, recording, processing, storing, displaying parametric and view information from the UAV; optical payload on a gyro-stabilized platform, which provides high-quality video monitoring with obtaining television and thermal imaging images of terrain and objects at any time of the day. “Burevestnik” UAV with a power unit based on an internal combustion engine and a wingspan of 9.2 m takes off from the runway and can stay in the air for up to 10–12 hours and due to its design features, the presence of a parachute rescue system and the materials used in its production has increased its reliability.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

“Burevestnik” UAV corresponds to the best world analogues. It has the following advantages:

- increased communication range (maximum ferry range (take-off from one airfield, landing at another airfield) is up to 1000 km);

- flight duration up to 12 hours;
- advanced payloads (TV, IR cameras with laser rangefinders, high-resolution cameras, equipment for measuring radiation levels);
- automatic tracking of a moving object;
- simplicity and reliability of operation;
- all-weather, resistance to strong winds;
- possibility of installing additional equipment. The maximum mass of payload (including the optoelectronic system) is up to 80 kg;
- possibility of modernization according to customer requirements;
- low visual, thermal, and acoustic visibility;
- resistance to interference, secure communication channels, operation in conditions of temporary absence of satellite navigation system signals.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Task 12.11 “Develop and implement in the Ministry of Emergency Situations an unmanned aerial system for monitoring emergency situations with a range of UAVs of 290 km”; subprogram “Creation and development of production of a range of technologies and elements of aircraft, payloads and unmanned aerial systems for multifunctional purposes”; State Scientific-Technical Program “Multifunctional unmanned aerial systems and technologies for their production”, 2011–2015; State Scientific-Technical Program “Robotic systems and aerospace technologies”, 2016–2020; subprogram “Robotic complexes and systems” of Scientific-Technical Program “Digital technologies and robotic systems”, 2021–2025.

#### Field of Application

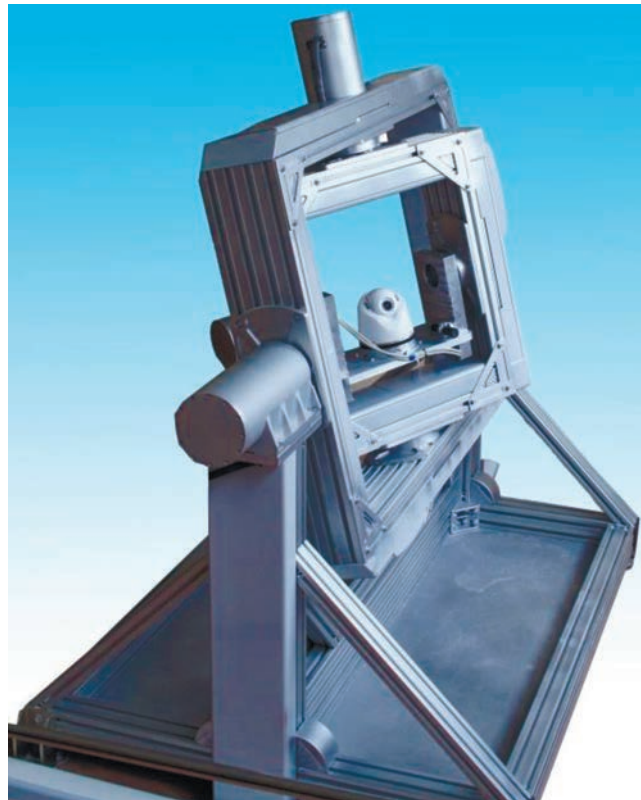
Performing surveillance, reconnaissance and data collection (with obtaining photo and video information, including in the visible and infrared ranges, in high resolution), air patrol, radiation monitoring of the area, search and rescue operations; carrying out aerial photography; relay of radio communication signals; use for scientific research and educational purposes; transportation of goods.

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**Republican Unitary Enterprise “Research and Production Center  
for Multifunctional Unmanned Complexes”**

**DYNAMIC THREE-AXIS BENCH  
FOR TESTING UAV MODULES**



**Development Description**

The bench is designed for testing angular velocity sensors, accelerometers, flight navigation systems, and gyro-stabilized video systems used in unmanned aerial vehicles.

The bench provides:

- movement along programmable trajectories to specified angular positions with a given law of change in angular velocity and acceleration;
- formation of motion trajectories with the required speed stability for testing angular velocity sensors;
- formation of harmonic oscillations;
- time-synchronous registration of setting parameters, current parameters of the motion trajectory and angular coordinates, payload parameters and signals;

- ease of fastening and adjustment of the axes and supporting surfaces of the payload with the axes of rotation of the gimbal;
- software setting of the limit value of the angular positioning error and angular velocity to control the functioning and disable the movement of the moving frames;
- program setting of angular velocity and time to disable the movement of the frames in case of emergency movement jamming;
- manual emergency shutdown of movement using buttons located on the operator's automatic workstation (AWS) and on the rotary support;
- movement along each axis in a circle, without limiting the angle of rotation.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The technical level in terms of positioning accuracy, ease of setting motion programs, and safety measures during the operation corresponds to world standards. The implementation of the bench allows for high-quality testing and calibration of sensors, which will increase the quality and reliability of unmanned aerial vehicles. The bench interacts with a simulator for training operators of unmanned aerial systems (UAS) and allows the use of semi-natural modeling methods.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program "Robotic systems and aerospace technologies", 2016–2020; task 14.11.

**Field of Application**

Testing of UAV modules and payloads.

**Contact Information of Organization-Developer**

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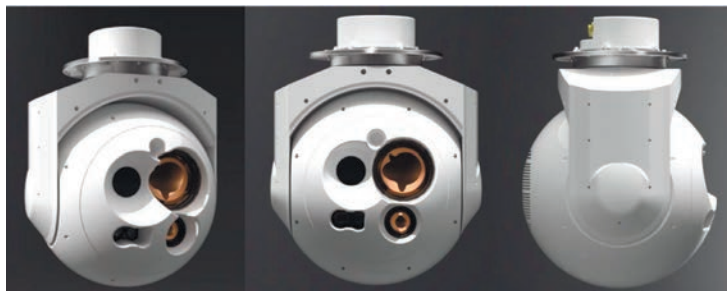
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**Republican Unitary Enterprise “Research and Production Center  
for Multifunctional Unmanned Complexes”**

**MULTIFUNCTIONAL SMALL-SIZED GYRO-STABILIZED  
VIDEO SYSTEM IN THE VISIBLE AND INFRARED  
WAVELENGTH RANGES WITH THE FUNCTION  
OF AUTOMATIC TRACKING OF GROUND OBJECTS**



**Development Description**

A multifunctional small-sized gyro-stabilized video system in the visible and infrared wavelength ranges with the function of automatic tracking of a ground object (MfMGV) is a payload for unmanned aerial systems (unmanned aerial vehicles) and is intended for:

- additional reconnaissance of area and single targets in the visible and infrared wavelength ranges in the altitude range of 150–3000 m;
- obtaining intelligence information in near real time;
- automatic tracking of a selected ground moving (stationary) object with determination of its coordinates and movement parameters in a mode close to real time, including the generation of control signals for controlling the MfMGV and UAV in the automatic tracking of a ground object mode.

The novelty lies in the development of original design solutions for a small-sized optical-electronic system on a gyro-stabilized platform, as well as in the development (adaptation, optimization) of computer algorithms for tracking ground objects to ensure the operation of the MfMGV as part of unmanned aerial systems. Algorithms and source code of special software for MfMGV have been developed, ensuring the implementation of the specified functions of MfMGV.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The technical advantages of the development are due to the layout of the MfMGV, namely:

- television module with 30× optical zoom;
- IR module with narrow field of view;
- additional IR module with
- a wide field of view;
- laser rangefinder module;
- gyro-stabilized electric drive;
- video processing and control module.

The mandatory arrangement of these modules in the MfMGV distinguishes it from domestic video systems for short-range UAVs, which use a set of interchangeable payloads: either a camera or an infrared reconnaissance module, either a television reconnaissance module or an uncontrolled surveillance video camera module. The presence of two IR modules (wide and narrow field of view), a TV module, a laser range finder, and an automatic object tracking module in the MfMGV distinguishes the development from domestic optical-electronic systems used as part of larger UAVs. The presence of an automatic object tracking module ensures the generation of control signals to the UAV flight and navigation system and to the MFMGV to control the position of its optical axis and change the UAV trajectory during automatic tracking of a ground object selected by the UAV operator. In terms of the “digital zoom” parameter, it surpasses the best foreign analogue video system by 1.3 times.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Digital technologies and robotic systems”, 2021–2025, subprogram “Robotic complexes and systems”, task 2.21 “Develop and put into production a multifunctional small-sized gyro-stabilized video system in the visible and infrared wavelength ranges with the function of automatic tracking of a ground object”.

#### Field of Application

Reconnaissance, detection, recognition and automatic tracking of ground objects, monitoring borders and territories, measuring and issuing coordinates of observed objects in real time.

#### Contact Information of Organization-Developer

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State Scientific Institution "Institute of Housing and Communal Services  
of the National Academy of Sciences of Belarus"

## HIGH EFFICIENT WATER SUPPLY SYSTEM



### Development Description

The equipment is designed to carry out the technological process of pumping and supplying water from artesian wells with a total mineralization (dry residue) not exceeding 1500 mg/l, with a pH value from 6.5 to 9.5, temperature up to 35 °C, with a mass fraction of solid mechanical impurities not exceeding 0.01 % (100 g/m<sup>3</sup>), with a chloride content not exceeding 350 mg/l, sulfates not exceeding 500 mg/l, hydrogen sulfide not exceeding 1.5 mg/l. The highly efficient water supply system consists of: a borehole centrifugal pump; permanent magnet synchronous electric motor; control and protection stations with frequency converter and telemetry. A downhole centrifugal pump and a permanent magnet synchronous electric motor are structurally combined into an electric pump unit.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The use of stainless steel and other modern materials in the design of the electric pumping unit allows extending the service life of the system; the equipment does not contain scarce or environmentally unsafe components; approximately twice cheaper than foreign analogues; experience of

using synchronous drives instead of asynchronous ones in the production conditions of the Republic of Belarus has shown that the specific power consumption of electric pumping units with synchronous motors is lower by 10 % in comparison with the world's best analogues with asynchronous motors (Germany), which ensures a return on investment in less than two years, despite the fairly high cost of synchronous drive systems (the cost of highly efficient synchronous systems is approximately 1.7–2.6 times higher than asynchronous ones); the equipment is characterized by a long service life and makes it possible to increase the operational life of the water supply system by approximately 1.5 times, while reducing water losses to 5 % during the water lifting process.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Agreement No. 7-2019 dated January 10, 2019 with “Zavod Promburvod” Open Joint Stock Company “Research and analysis of production and economic conditions for the operation and implementation of pumping units with a synchronous drive for lifting water from artesian wells in the Republic of Belarus”; Agreement No. 23/06 dated June 23, 2021 with “Zavod Promburvod” Open Joint Stock Company “To provide scientific and methodological support for the development of production of energy-efficient pumping units for water intakes in drinking water supply systems” 2019–2023.

#### Field of Application

Water supply systems in the following industries: housing and communal services, energy, construction, industry, agriculture and forestry.

#### Contact Information of Organization-Developer

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State Scientific Institution “Institute of Housing and Communal Services of the National Academy of Sciences of Belarus”

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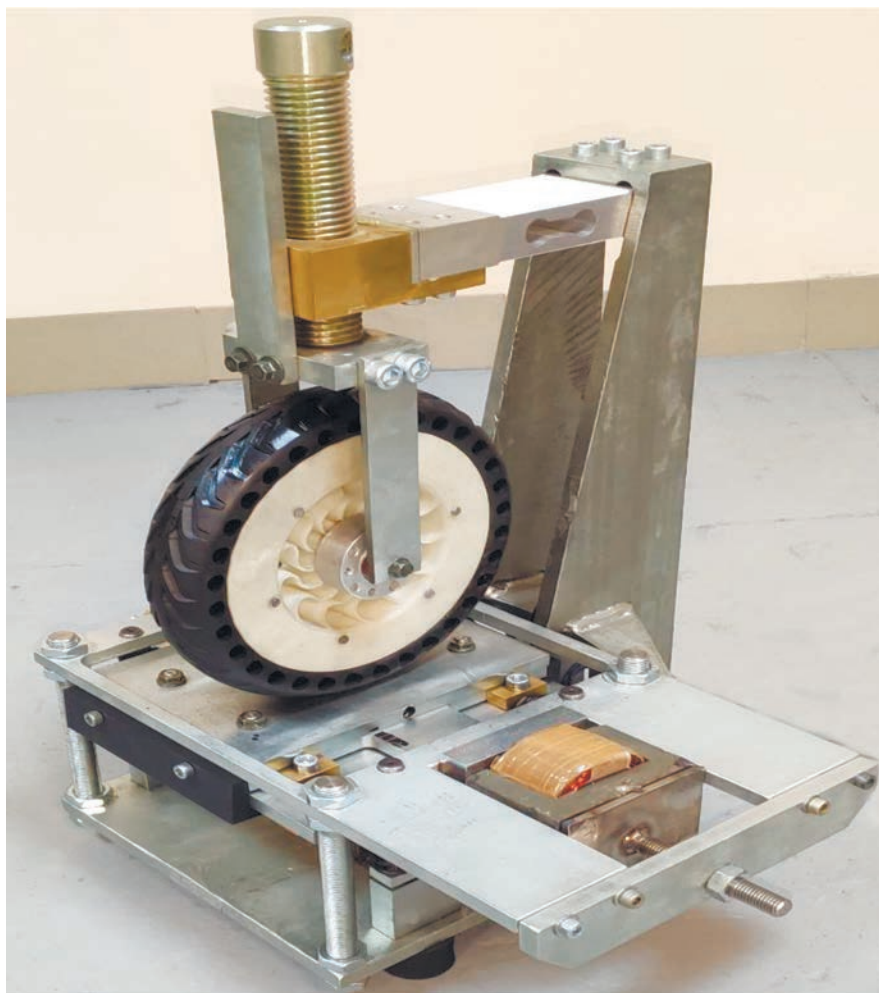
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Open Joint Stock Company "Instrument-Making Plant Optron"

## AIRLESS WHEEL



### Development Description

Methods for testing tires for personal mobility devices have been developed, the properties of polymer and composite matrices that affect the strength characteristics of airless tires have been studied, making it possible to improve the technical and economic indicators during the operation of vehicles.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no analogues in the world.

**Intellectual Property Protection:**

- Stand for testing wheels and tires: BY u20210209/ Stand for testing wheels with tires: application BY u20210209 / Patotsky D. A., Yankevich S. N., Volochko A. T. – Publ. 08/10/2021;
- Stand for testing wheels and tires: useful. model BY No. 12783 / Patotsky D. A., Yankevich S. N., Volochko A. T. – Publ. 08/10/2021;
- A method for determining the stiffness and damping properties of tires, and a stand for its implementation: application BY a20220163 / Patotsky D. A., Yankevich S. N., Volochko A. T. – Publ. 06/16/2022.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Materials Science, New Materials and Technologies”, 2021–2025, “Development of composite materials, structures and technologies for creating airless tires for electric vehicles” on task 4.1.37 “Development of composite materials, structures and technologies for creating airless tires for electric vehicles”.

**Field of Application**

Production of vehicle components, aviation.

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Open Joint-Stock Company "NPO Center"

## CRANIO-CAUDAL HYPERGRAVITY THERAPY UNIT



Prototype Cranio-Caudal Hypergravity Unit

### Development Description

Gravitational therapy is one of the new physiotherapeutic methods. It is based on the effect of gravity on the body at different positions of the body relative to the vector of action of this force. Hypergravity therapy should be considered as a method of general exposure with the therapeutic and preventive purpose of artificial gravity exceeding the earth's gravity by a factor



of up to 3 units. The cranio-caudal hypergravity therapy facility is used in the complex treatment of patients and in some cases allows avoiding surgical treatment, achieving a faster and more stable effect from the treatment, improving the quality of life of patients. To expand diagnostic and therapeutic functions, the device can be used in conjunction with additional equipment for pulse oximetry, blood pressure monitoring, exposure to therapeutic physical factors and exercise.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no analogues of domestic production. The device has no defective and environmentally unsafe components; cheaper than foreign counterparts; characterized by a long service life; expands the range of medical products; has a therapeutic, general strengthening effect.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SP “High-Tech Technologies and Engineering” for 2021–2025, subprogram 2 “Development in the production of new and high technologies”, task 18 “Develop and organize the production of an installation for hypergravity therapy in the cranio-caudal direction”.

**Field of Application**

The main areas of clinical use of the cranio-caudal hypergravity therapy device are rehabilitation medicine in traumatology and orthopedics, surgery, in the treatment of vascular pathologies, diseases of the nervous system, diseases of the urogenital system.

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Open Joint-Stock Company "NPO Center"

## CENTRIFUGAL-IMPACT CRUSHERS DC WITH INTEGRATED DEDUSTING SYSTEM



### Development Description

The centrifugal impact crusher with additional dedusting system and new self-fluffing system for dry processing of highly abrasive materials such as electrocorundum, silicon carbide, boron carbide with minimum NTU index. The new wear-resistant crusher design allows reducing energy costs, increasing equipment reliability, and reducing wear of the main structural working element, on the one hand, and achieving high capacity, obtaining the quality of the finished material required by the technological process, preventing critical milling of metal and the growth of operating costs for the process, on the other hand.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The closest competitor is the equipment of Western companies, which do not have complete, full-featured proposals for obtaining high-quality, dust-free materials using the dry method. Most manufacturers are forced to use wet dust removal lines. However, such lines are significantly inferior to the dry method in terms of the total cost of the line and applicability due to limited use in water-free zones and in zones with low seasonal temperatures.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Supply contract with PJSC “Zaporozhye Abrasive Plant” (Zaporozhye) №003945/21BH dated 10.02.2021.

**Field of Application**

Production of powders of highly abrasive materials, such as electrocorundum, silicon carbide, boron carbide, etc. in the interests of the chemical industry and construction materials production.

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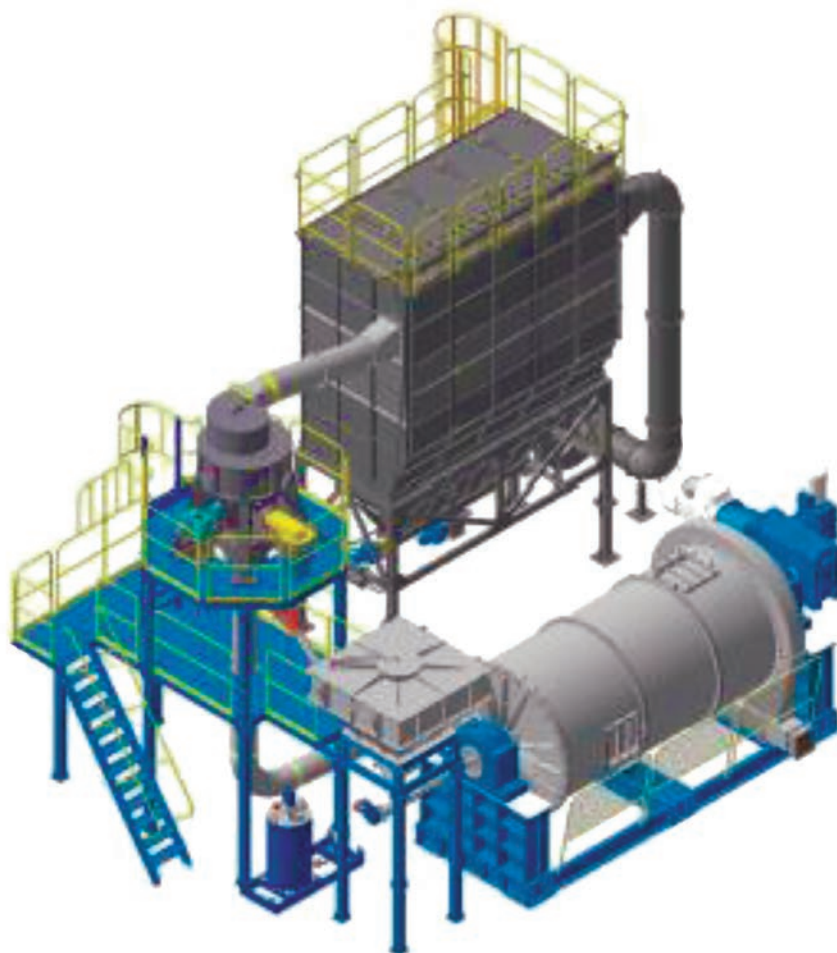
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Open Joint-Stock Company "NPO Center"

## TECHNOLOGICAL PLANTS FOR OBTAINING MINERAL POWDERS



### Development Description

Technological plants use technology consisting of 3 main processes:

- Centrifugal-impact milling operating in a cycle with built-in classification. After preliminary crushing centrifugal-impact milling plants produced in series by NPO CENTER are used to receive the initial feed size of 0–20 mm. They allow reducing energy consumption for the process at the first stage of milling, at the same time the reduction of feed size of the subsequent stage of fine milling allows significantly increasing the line capacity.
- High-intensity impact milling. The highly efficient design of the mill with its own aspiration system corresponding to the analogues of the leading

western companies has been developed and manufactured. The design provides the possibility of making the lining and milling bodies from ceramic materials to minimize metal fouling and preserve the whiteness index. The necessary functional properties of modified mineral powders are achieved by the formation of target structures on the particles surface by “grafting” the modifier to their surface by the molecular layering mechanism. One of the most effective ways of surface modification of mineral fillers is the combination of milling, modification with target surfactants, and mechanical activation. To ensure the possibility of effective modification of powders to give them target properties, reduce energy consumption for the milling process, and obtain finer powders, the plant includes a modifier feeding system which feeds liquid modifiers (dependant on the type of material obtained) into the active milling zone at a predetermined flow rate.

- Highly efficient classification. This equipment is produced by no more than 10 companies in the world and its cost largely determines the high total cost of the complete plant. For the implementation of this technology the prototype of the classifier of fine powders with aspiration system in a standard configuration was designed. The final configuration of the classification plant depends to a large extent on the properties of the separated material and the classification efficiency is predicted with high accuracy on the basis of the calculation methods incorporated in the control system. The final composition of the classification system and control system is determined after the approval of the technical specification (TS) for solving a specific production problem.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Advantages:

- in relation to the best domestic samples: has no analogues;
- in relation to the best world samples: at the level of world analogues; specific power consumption for obtaining a ton of mineral powder (coarseness D98 = 10 microns) – 106.7 kWh/t. The electricity saving in comparison with the best foreign analogues is 20–30 % in average; the cost of the plant for production of ultrafine modified powders of mineral materials in a complete set (including a classifier of ultrafine powders, aspiration system, and return system) – in comparison with the best foreign analogues is 1.9 times lower; import intensity (the share of imports in the unit cost, in %) is about 10–20 %.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-intensive technologies and engineering”, 2016–2020; subprogram 2 “Mastering of new and high technologies in production”; task 21 “Development and mastering of the production line for obtaining ultrafine modified powders of mineral materials”.

**Field of Application**

The created plant is designed for obtaining ultrafine modified powders of mineral materials with particle size mainly less than 0.01 mm with high homogeneity and whiteness with almost complete absence of harmful ferrous impurities. It can be used in obtaining such micropowders as:

- electrocorundum – used for production of grinding pastes;
- zeolite – used in the pharmaceutical industry, in particular, for production of the well-known drug “Smecta”, etc.;
- marble, calcite, chalk – size of 98 % of particles is less than 10 microns, used in paint and varnish industry;
- pigments – processing of pyrite cinders or other materials based on iron oxide many of which are industrial wastes, average particle size – 3–3.5 microns;
- cement – cement micropowders are used for obtaining rapidly hardening compositions, production of cement-based waterproofing mastics, high-strength concrete;
- talc – paint and varnish industry, pulp and paper industry, plastic fillers (plastic elements of car bodies);
- zinc borate – powder with average particle size less than 3 microns, used for production of non-combustible insulation of electric wires and cables;
- graphite – production of melting crucibles, lining plates, electrodes, heating elements, production of chemically active metals by electrolysis of molten compounds, solid lubricants, plastic fillers, neutron moderators in nuclear reactors, production of synthetic diamonds, for production of thermal protection of the nose part of warheads of ballistic missiles and re-entry spacecraft;
- ground glass – paints for roads, high wear resistance and light reflection.

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State Scientific Institution "A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus"

## SILICON CARBIDE CERAMIC MIRRORS FOR SPACE OPTICAL SYSTEMS



### Development Description

The technology for silicon carbide production with better combination of thermophysical and mechanical properties among the known analogues applied during astronomical mirror development has been developed. The technology for rapid mechanical processing and fabrication of complex geometry products of super-hard silicon carbide ceramics has been developed. A series of experimental samples of ultra-light substrates of 205 mm dia silicon-carbide mirror has been produced, which is characterized by low specific weight of  $16.5 \text{ kg/m}^2$ , which is comparable to the best world counterparts.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Maksutov criterion, which constitutes the product of mechanical Q factor of the material and its thermal Q, is a major one to evaluate the quality of the material to be applied in optic systems (mirrors, lenses). The higher this



criterion is, the better quality of the optical image can be achieved, when applying it for fabrication of the mirrors for telescopes, cameras, etc.

The Table gives the comparison of the developed material (Si/SiC HMTI) with those of the world producers of optical systems on the basis of open literature references. As it can be seen, in accordance with Maksutov criterion the developed material is at the level of the best world counterpart – silicon carbide ceramics by Boostec fabricating the silicon-carbide mirror with the aperture of 3.5 m for Herschel mission carried into Lagrange point in 2009.

The integral characteristic of the mirror quality in space applications is its specific weight per unit area. Lighter mirrors have the advantages. The transition from optical glass to silicon carbide has allowed reducing the mirror weight: from 190 kg/m<sup>2</sup> for 2.4 m glass mirror of the Hubble telescope to 27 kg/m<sup>2</sup> for 3.5 m silicon carbide mirror for Herschel mission (2009). The silicon carbide mirror specimens developed by Heat and Mass Transfer Institute possess specific weight of 17 kg/m<sup>2</sup> demonstrating the level of the best world analogues.

**Comparison of Physical and Mechanical Properties of Materials for Optical Substrates**

Material	Producer	$\rho \times 10^{-3}, \text{ kg/m}^3$	$\lambda, \text{ W/(mK)}$	TEF $\alpha \times 10^6, \text{ K}^{-1}$	$C_p, \text{ J/(kg K)}$	E, GPa	Maksutov criterion, $\text{Mk} \times 10^{12}, \text{ kg m K s}^{-3}$
<b>Glass and glass ceramics with Ultra-low thermal-expansion coefficient</b>							
ULE glass	Corning	2.20	1.31	0.03	766	67	1.7
Zerodur	Schott	2.53	1.46	0.05	821	92	1.3
Fusedsilica	Heraeus	2.20	1.38	0.5	772	73	0.1
Astrosital	LZOS	2.46	1.99	0,15	920	92	0.5
<b>Beryllium</b>							
HIP beryllium	Brush-Well-man	1.85	180	11.3	1925	303	1.3
<b>Silicon carbide seramics</b>							
Si/SiC	HMTI	3.14	185	2.1	630	420	18.7
BoostecSiC	Boostec	3.15	180	2.0	680	420	17.6
NT-SiC	NEC SpaceTechnol.	3.02	130	3.9	680	400	6.5
Cesic	ECM	2.65	135	2.6	660	235	7.0
C/SiC	MELCO	2.8	130	2.3	671*	320	9.6
Reaction-bonded (RB) SiC	HarbinInstofTechnol.	3.09	161	3.5	594	362	9.1
PAD-B SiC	Cercom	3.2	130	4.5	670	455	6.1
SuperSiC-Si	Entegris	2.93	170	2.0	671*	232	10.0
Ceraform	Xinetics	2.95	172	3.4	670	364	9.3

The mirror specific weight ( $\text{kg/m}^2$ ) made of optical glass (blue area of the diagram), silicon carbide (grey area), and beryllium (pink area) applied in space optic tools (solid markers) and mirrors produced within the framework of different missions (hollow markers). M1, M2, M3 – primary, secondary, and tertiary mirrors of optical systems, respectively.

#### Intellectual Property Protection

Patents of the Republic of Belarus No. 23438, 23137, 22756.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Contract KACST-HMTI/27 for 2017–2019.

#### Field of Application

Space technologies, optic technologies.

#### Contact Information of Organization-Developer

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State Scientific Institution "A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus"

## MULTIFUNCTIONAL SCANNING PROBE MICROSCOPE



### Development Description

The system is designed to register optical, fluorescent, and AFM images of biological objects, study the cells and their organelles at micro and nano level, and evaluate local elasticity and adhesive ability of the cells.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Optical magnification – up to  $\times 300$ . Resolution in AFM mode – 5–10 nm. Scanning area in AFM mode – up to  $100 \times 100 \mu\text{m}$ . Continuous operation with working volume thermostating – up to 170 hours. Working area temperature –  $24\text{--}27 \pm 0.5 \text{ }^\circ\text{C}$ . The module type of the system allows integrating with other optical and spectral facilities in accordance with the tasks of the performed investigations. The research system can be adapted to

particular research goals of the customer. Corresponds to the best world analogues.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Industry Scientific-Technical Program “Nanomaterials, nanostructures, and nanotechnology” (ISTP “Nanoindustry”), 2015–2017; task 5 “Develop a research complex for automated assessment of the state of nano- and microstructures of biological cells in the process of their vital activity in vitro by methods of optical, fluorescent, and atomic force microscopy and organize its production”.

**Field of Application**

Industry.

**Contact Information of Organization-Developer**

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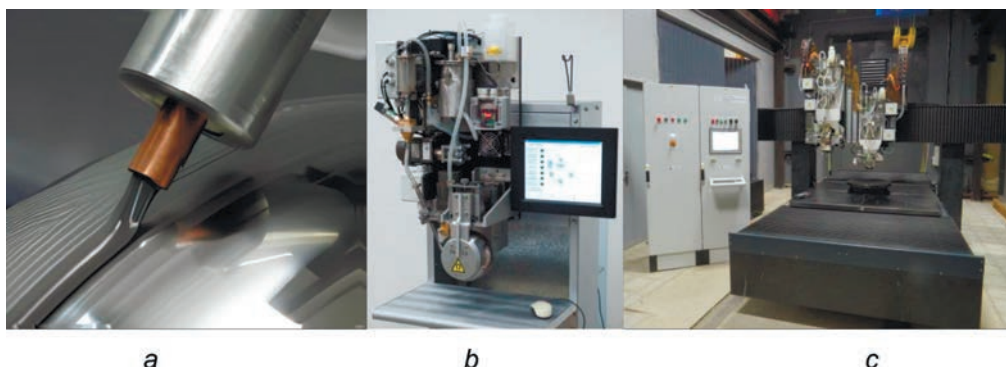
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State Scientific Institution "A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus"

## TECHNOLOGIES AND EQUIPMENT FOR MAGNETORHEOLOGICAL TREATMENT OF PRECISION COMPONENTS



General view of the equipment for magnetorheological treatment: *a* – supply of MRF fluid from the nozzle on the working wheel; *b* – module for MRT with control system; *c* – 8-coordinate machine for treatment of the products of up to 1.5 m

### Development Description

The technologies of critical part treatment based on controllable variation of rheological properties of magnetorheological polishing fluid (MRF) under the influence of magnetic field; 3–8-coordinate CNC machines for magnetorheological treatment (MRT) with natural stone base and servo-drive application; 1–2-coordinate modules to additionally equip machines and coordinate systems. Magnetorheological polishing fluids on aqueous and anhydrous basis. Workpiece dimensions – from 3 mm to 2.5 m. Machining allowance amount to up to 5  $\mu\text{m}$ .

Materials: optical glass, silica, glassceramic, zerodur, silicon, germanium, tungsten carbide, silicon carbide, KDP water-soluble crystals, BBO, nonmagnetic stainless steels, aluminum-, copper-, nickel-, and titanium-based alloys, etc.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The machines, modules, and MRP fluid allow making automated treatment of flat, spherical and aspherical surfaces of unique products with the accurate RMS shaping up to  $\lambda/150$  and surface roughness  $R_q$  up to 1 Å.

By applying CNC machines the treatment time is reduced and the product quality is increased. The industrial technology application does not require vacuum and use of chemically aggressive substances. Physical factors (power, noise, radiation, etc.) do not exceed allowable values. MRT are successfully utilized by QED Technology (USA) and CIOMP (China).

#### Intellectual Property Protection

Patent of the Republic of Belarus No. 12603; Patent of the Russian Federation No. 2569877; Eurasian Patent No. 024869.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

The developments were carried out as part of the implementation of foreign trade contracts with the Russian Federation, China, and the countries of the Middle East (2013–2022). The scientific support was provided under tasks of State Research Program “Energy Systems, Processes, and Technologies”, 2016–2020 and Scientific-Technical Program of the Union State “Development of complex technologies for creating materials, devices, and key elements of space systems and promising products of other industries” (“Technology-US”, 2016–2020).

#### Field of Application

Optic and microelectronic industry.

#### Contact Information of Organization-Developer

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Website: <http://www.itmo.by>

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State Scientific Institution “A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus”

## PYROMETER PIF 18



### Development Description

PIF 18 Pyrometer is designed for non-contact measurement of the temperature dynamics in fast-running thermal processes in case of unavailable information about radiating capacity of the object and can be applied both for scientific studies and thermal monitoring of the fast-running technological processes.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The principle of PIF 18 operation is based on photo-emission method of the temperature measurement, which minimizes the influence of object radiating capacity on measurement accuracy. The given method is not used in commercial pyrometers designed for similar purposes, therefore PIF 18 pulse photo-emission pyrometer has no real counterparts. The pyrometer enables non-contact temperature measurement from 1200 to 2900 K with log time resolution up to 1  $\mu$ s (100, 10, 5, 2 and 1  $\mu$ s) by registering the object in spectral range of 400–800 nm. The working distance to the object without lens replacement can be from 0.45 to 5 m. The device possesses laser positioning system and tripod-fixing option. The removable lens

module of the pyrometer allows using a flexible optical fiber. The facility does not require introducing the value of object radiating capacity prior to temperature measurement.

#### Intellectual Property Protection

PIF 18 pulse photo-emission pyrometer has been included into the State Registry of Gauges, Certificate No. 13488.

Utility Model Patents of the Republic of Belarus No. 12171 and 12604.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of integrated technologies for creating materials, devices, and key elements of space vehicles and promising products of other industries” (“Technology-US”, 2016–2020); task 1.2.4.2 “Develop a pulse photoemission pyrometer for non-contact measurements of high temperature in conditions of uncertainty of the radiation coefficient for quality control in the processes of manufacturing and testing of structural elements of spacecraft”.

#### Field of Application

Industry:

- high-speed temperature variation in heat-intensive units of propulsion systems and fuel combustion products during combustion optimization and control;
- metal melting temperature measurement;
- surface temperature control in thermal treatment and fabrication of materials and construction components of micro electromechanical systems, including small space vehicles;
- thermal control of high-speed processes during laser treatment of materials and in technologies of production of composite carbon-containing high-strength coatings.

#### Contact Information of Organization-Developer

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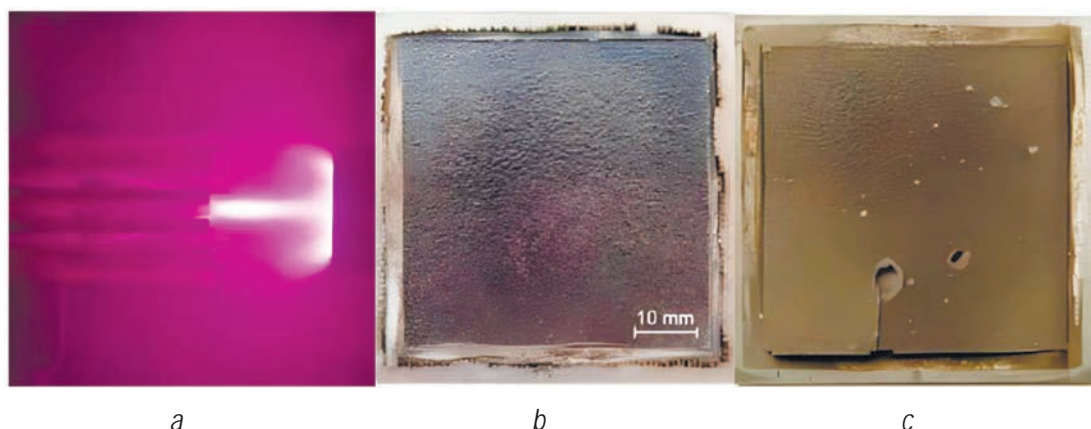
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State Scientific Institution "A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus"

## TECHNOLOGICAL PRINCIPLES OF DEVELOPING THE COMPONENTS OF THE METEOROID SHIELDING OF HIGHER DURABILITY FOR SPACE VEHICLES



Developing the components of screen antimeteorite protection of higher durability: *a* – modification of the component under the effect of compression plasma flow; *b* – modified component of the meteoroid shielding; *c* – element of the meteoroid shielding of higher durability after the tests in the ballistic facility

### Development Description

Meteoroid shielding components of higher durability for space vehicles possess two-layer composite coatings (viscous metallic layer and the one of solid ceramic material) modified by the compression plasma flow generated by the quasi-stationary high-current plasma accelerator, i. e. magnetic plasma compressor.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Test results of the developed meteoroid shielding components have shown that the elements possess high resistance to the impact of high-speed particles (diameter of 0.5–2.5 mm, velocity of 0.3–5.0 km/s) compared to the meteoroid shielding specimens fabricated under conventional technologies. The developed technological process of fabricating the meteoroid shielding components of high durability has no analogues and has priority nature.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-Technical Program of the Union State “Development of space and ground-based means of providing consumers of Russia and Belarus with Earth remote sensing information (“Monitoring-US”, 2013–2017); task “Develop a manufacturing technology and experimental samples of high-resistance screen anti-meteor protection elements optimized for composition, coatings, and mass characteristics for spacecraft systems”.

**Field of Application**

Meteoroid shielding of space vehicles

**Contact Information of Organization-Developer**

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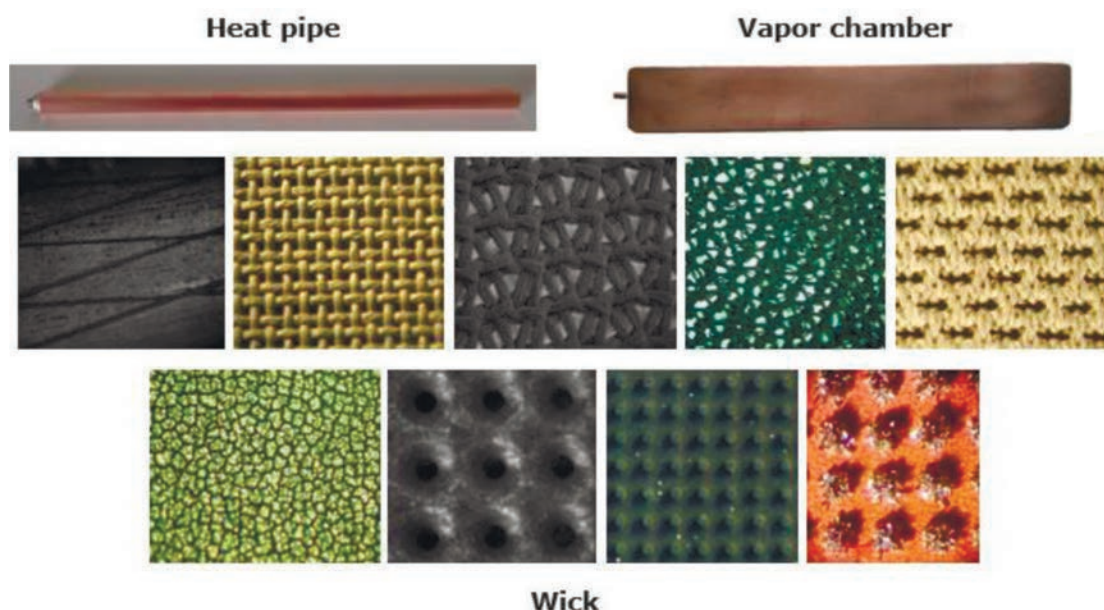
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State Scientific Institution "A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus"

## VAPOR CHAMBER AND HEAT PIPE COOLING SYSTEMS



### Development Description

One of the possible options for solving the problem of reliable removal of the emitted thermal power is the creation of a highly efficient heat removal and cooling system. High efficiency of the system can be ensured by using a combination of various methods of heat removal, including those based on changing the aggregate state of the coolant. In particular, the use of efficient cooling systems based on vapor chambers and heat pipes allows solving the problem of thermal stabilization of electronic components, as well as heat removal from hard-to-reach powerful point sources and its redistribution. Experimental samples of heat pipes with high heat-transfer capacity (maximum transfer power – 85 W) in a wide range of thermal loads, with high isothermal properties (thermal resistance of pipes in horizontal orientation is 0.1 K/W) have been manufactured. Also developed are compact vapor chamber samples for various applications, including mobile ones, with high heat transfer capacity (from 20 W with a chamber thickness of 0.4 mm to 85 W with a thickness of 3 mm), high isothermality (thermal resistance from 0.1 K/W with a thickness of 3 mm to 1.8 K/W with a chamber thickness of 0.4 mm). In addition, they are resistant to deep freezing, vibration; are gravity-independent; have a low cost.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Unlike foreign analogues, the developed products have high heat transfer capacity, low thermal resistance with a small sample thickness.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Business contract with Bel Huawei Technologies LLC (China) "Heat pipe with an adiabatic compensation zone" dated 04/22/2020. Implementation period: 04/22/2020 – 09/07/2020.

**Field of Application**

Cooling systems for heat-loaded elements and devices of electronics, mechanical engineering, cooling/heating systems for building structures.

**Contact Information of Organization-Developer**

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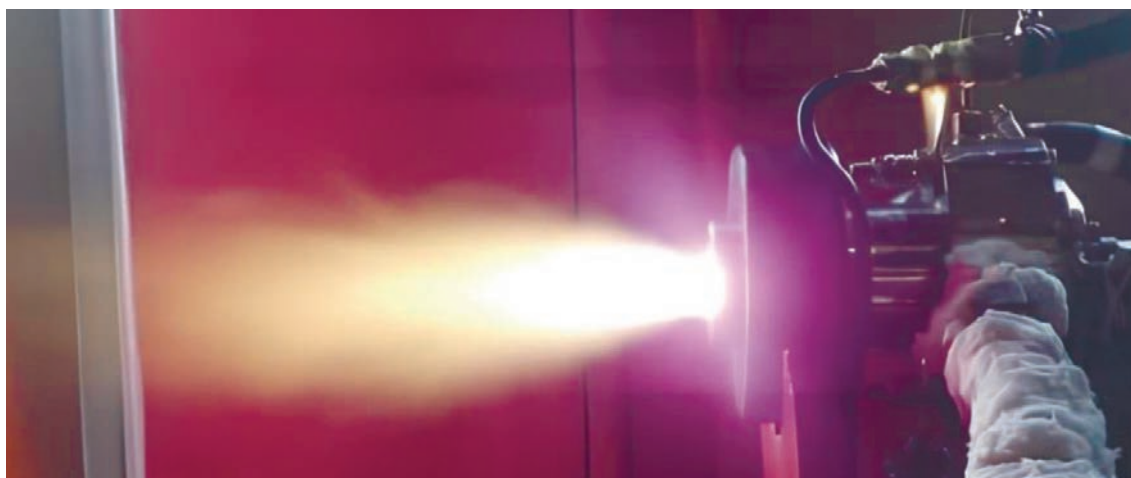
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State Scientific Institution "A. V. Luikov Heat and Mass Transfer Institute  
of the National Academy of Sciences of Belarus"

## **60 KW PLASMA TORCH (PLASMA GENERATOR)**



### **Development Description**

DC plasma torch generates a high-temperature flow of steam-conducting plasma. The plasma torch power is adjusted between 30 to 60 kW.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The plasma torch can be used for scientific studies in the field of high-temperature processing (gasification) of organic materials, as well as for melting (vitrification) of refractory materials, e. g. ash. In contrast to foreign counterparts, the plasma torch can use both humid and overheated steam and air as a plasma-forming gas. The electrode service life is up to 1200 hours.

### **Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

AGREEMENT No. ИТМО-КБАЦНП/2019-09 dated 16.09.2019 "Development and Manufacture of a Direct Current Plasma Torch (PLASMOTRON) (Air and Steam) with Capacity of 60 kW" with Chinese-Belarusian High-Tech Aerospace Research and Development Center LLC (Republic of Belarus).

### **Field of Application**

Industry.

Contact Information of Organization-Developer

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State Scientific Institution “Joint Institute of Mechanical Engineering  
of the National Academy of Sciences of Belarus”

## OIMOL CL BIO BIODEGRADABLE GREASE



### Development Description

The technological process of obtaining OIMOL CL BIO biodegradable grease with the letter “O1”. It is an environmentally friendly lubricant designed to lubricate small and medium unloaded friction units of various machines and mechanisms operating in conditions where increased environmental protection requirements are applied. It is recommended for use in the temperature range from  $-30$  to  $+120$  °C.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Corresponds to the best world analogues. Technical characteristics: drop-off temperature, °C: not lower than 200; penetration,  $10^{-1}$  mm: range 265–295; colloidal stability, %: not more than 5.0; mass fraction of mechanical impurities, wt. %: not more than 0.03; biodegradability, %: not less than 80.

### Intellectual Property Protection

Patent BYN $\text{\textcircled{2}}$ 23651. The technical specifications of TRBY190410065. 0212020 “Biodegradable grease” have been developed and registered.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Program “Innovative technologies and equipment”, 2017–2020; task 3 “Develop technologies and create production of a new generation of nano-dispersed oils and lubricants based on biodegradable domestic renewable raw materials”.

### Field of Application

Agricultural and logging machinery, technological equipment of processing and light industry, mining industry.

### Contact Information of Organization-Developer

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State Scientific Institution "Joint Institute of Mechanical Engineering  
of the National Academy of Sciences of Belarus"

## EQUIPMENT AND TECHNOLOGY FOR RESTORATION – STRENGTHENING OF QUICK-WEARING PARTS OF MACHINES AND STRUCTURAL ELEMENTS USING HYPERSONIC METALLIZATION METHOD



### Development Description

Technological processes and equipment for creating composite wear- and corrosion-resistant coatings formed by hypersonic metallization as applied to tribo-couplings of mechanical and hydraulic systems.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Restoring of worn-out rods of power hydraulic cylinders by applying hypersonic metallization coatings followed by tribomechanical modification leads to a more than doubling of service life. The formation of wear-resistant chromium-containing coatings by hypersonic metallization instead of galvanic chromium plating eliminates the need for disposal of toxic waste. A hypersonic metallization unit for applying wear and corrosion-resistant coatings using high-speed spraying of wire materials reduces operating costs by 2–5 times compared to foreign high-speed spraying units.

### Intellectual Property Protection

Eurasian patents: No. 024778, 025873, 032173, 032976, 037491, 039515; Patents of the Republic of Belarus: No. 20975, 20946, 21562, 22381, 23128, 23212.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Mechanics, metallurgy, diagnostics in mechanical engineering”, 2016–2020; subprogram “Mechanics”; task 1.09.2 “Development of methods for ensuring resource parameters of high-tech components of mechanical, hydraulic and mechatronic systems based on the creation and use of new composite materials, coatings and technologies for surface modification, methodology for expert assessment of predicted and express analysis of the obtained properties of materials” (state registration No. 20162334).

**Field of Application**

Mechanical engineering, agricultural engineering, repair of automobile and railway transport, petrochemical industry.

**Contact Information of Organization-Developer**

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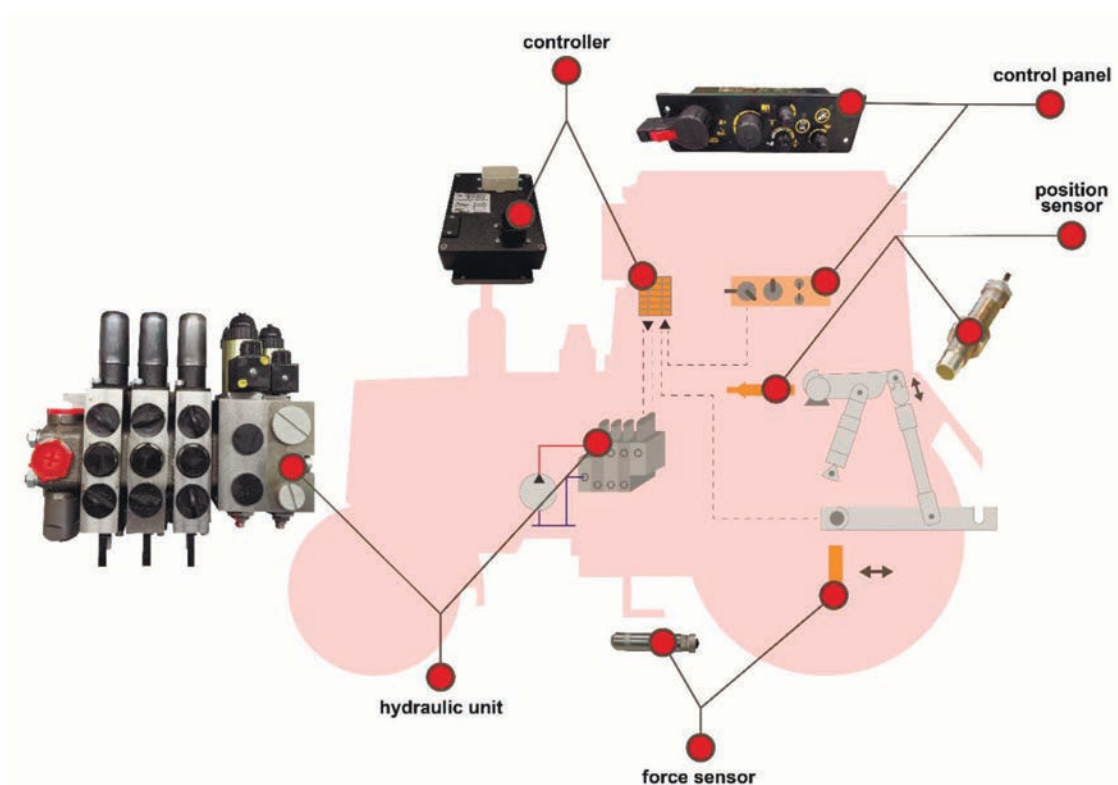
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State Scientific Institution "Joint Institute of Mechanical Engineering  
of the National Academy of Sciences of Belarus"

## ELECTRO-HYDRAULIC CONTROL SYSTEM OF PLOWING UNIT WORKING BODIES



### Development Description

In automatic mode (draft, position and mixed control) the control system makes it possible to maintain the plowing depth set by the operator on the control panel within the agrotechnical requirements by determining the deviation of traction resistance and position of the attachment relative to the tractor frame by means of appropriate sensors electrically connected with the controller to form a control action from the hydraulic block regulator to the input of the power hydraulic cylinder. The control system provides reduction of fuel consumption by means of the algorithm of the control action formation and increase of operational reliability at positioning of working bodies by using non-contact principle of measurement of attachment movement, and its lower cost in comparison with foreign analogues is achieved due to simplification of the regulator design.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

High reliability and increased accuracy of operation due to the non-contact principle of measuring the position of the attachment's pivot shaft and the elimination of the influence of radial wear in the pivot shaft bearing points. The use of the system improves the quality of tillage operations while reducing fuel consumption.

The system corresponds to world analogues (import substitution).

#### Intellectual Property Protection

Patents of the Republic of Belarus: No. 4521, 11260, 23484; Patent of the Russian Federation No. 175 337; Eurasian patent No. 039622.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

– State Scientific-Technical Program “Mechanical Engineering and Mechanical Engineering Technologies”, 2013–2015; subprogram “Mechanical Engineering”; task AT06.34 “Develop and master production of import-substituting electrohydraulic regulator of flanged design for hydraulic control unit with sectional distributor RP-70” (state registration No. 20130494).

– Union State Program “Development of a new generation of electronic components for control and safety systems of special and dual-purpose vehicles” (“Autoelectronics”, 2016–2020); task 1.8 “Development of electrohydraulic control system for energy-saving drives of mobile machines” (state registration No. 20163921).

– State Scientific-Technical Program “Mechanics, metallurgy, diagnostics in mechanical engineering”, 2016–2020; task 1.04 “Synthesis of precise and highly dynamic electromechanical”.

#### Field of Application

Agricultural and road-building engineering.

#### Contact Information of Organization-Developer

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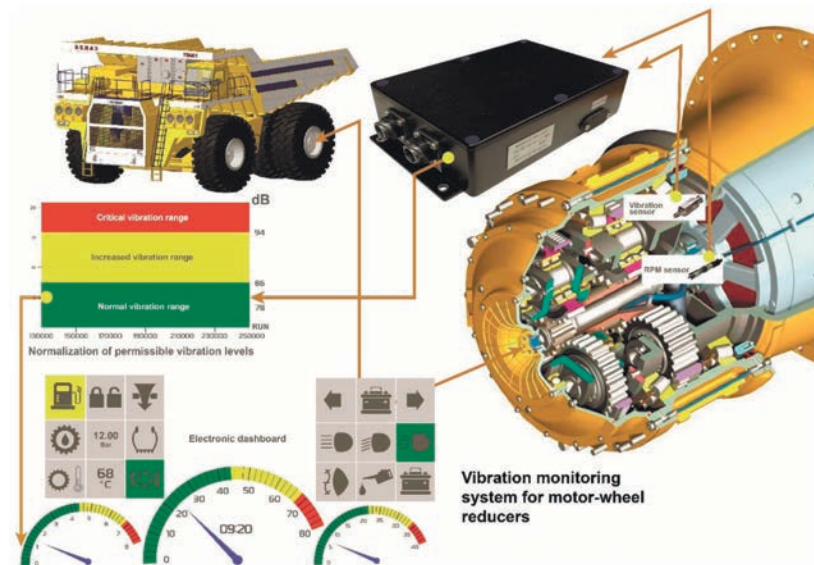
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State Scientific Institution "Joint Institute of Mechanical Engineering  
of the National Academy of Sciences of Belarus"

## ON-BOARD SYSTEM FOR MONITORING THE TECHNICAL CONDITION OF GEARBOXES OF BELAZ MINING DUMP TRUCK



### Development Description

A modernized CBM-PMK-420 vibration monitoring system designed for autonomous use on BELAZ dump trucks, as well as an on-board CBM-420I vibration monitoring kit designed for use as part of the Intelligent Global Monitoring and Predictive Analytics System as an on-board device. Functional, computing, and communication capabilities of the vibration monitoring system are expanded through the implementation of wireless data transmission and software development.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

- Recording and storage in non-volatile memory of vibration parameters of 2 dump truck GM required for evaluation of their technical condition within the specified time interval;
- conducting on-board monitoring of the general technical condition of the GM by the boundary values of vibration parameters during the technological cycle of the machine in the quarry. Indication of critical states of the

GM and visualization (if necessary) on the instrument panel of the machine of the main criteria parameters of vibration;

- generation of GM vibration monitoring data packets for a given period of time, recording and storing this data on a flash card and transmitting them via the CAN interface to the GSM module via an appropriate protocol, and then transmitting these packets via the GSM cellular communication system to the Internet;

- organization of receiving data on vibration monitoring of BELAZ dump trucks and transmission of service information to the server. Collection, sorting and processing of vibration state data of the GM, collected during a given operation cycle (for example, during the service interval of the machine operation) from various machines;

- generation of GM vibration monitoring databases on the server for a number of machines, ranking of these data according to the specified criteria, construction of GM vibration state trends and, furthermore, use of the software platform for in-depth diagnostics to identify defects at the level of units and elements of BELAZ dump trucks GM.

- developments can also be used as a vibration diagnostic tool for units with gears operating at variable speeds and loads, for automatic control and vibration diagnostics of gearboxes in order to prevent their emergency failure and assess the technical condition during operation.

The system corresponds to CIS analogues.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Contract with BELAZ OJSC dated 10.12.2019 No. 600-03420 “Upgrade the on-board vibration monitoring system in terms of providing automated wireless transmission of diagnostic data and develop a methodology for its use on BELAZ dump trucks” (2019–2023).

#### Field of Application

Mechanical engineering, in particular the automotive industry, wheeled vehicles and transport and technological complexes, transport.

#### Contact Information of Organization-Developer

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State Scientific Institution "Joint Institute of Mechanical Engineering  
of the National Academy of Sciences of Belarus"

## UNIT FOR LASER MICRO-PROCESSING OF MICROELECTRONIC MATERIALS



### Development Description

Apparatus for dividing into crystals by laser processing of thin substrates of sapphire microcircuits used to make silicon-on-sapphire microcircuits for space and special equipment, developed jointly by the Joint Institute of Mechanical Engineering and Planar OJSC.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The installation corresponds to world analogues (import substitution).

### Intellectual Property Protection

EURASIAN patent for invention No. 040628 "Installation and method of laser micro-processing of electronics materials", 2022 (patent owners are

SSI “Joint Institute of Mechanical Engineering of the National Academy of Sciences of Belarus” and OJSC “Planar”).

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-Tech Technologies and Engineering” for 2021–2025, subprogram 2 “Development in the production of new and high technologies”, task 6 “Develop and master the production of a laser micro-processing installation for electronics materials”.

**Field of Application**

Mechanical engineering.

**Contact Information of Organization-Developer**

SSI “Joint Institute of Mechanical Engineering of the NAS of Belarus”

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**Planar (KBTEM)**

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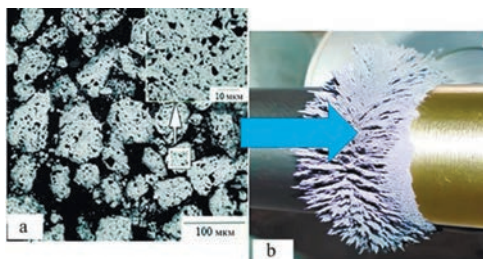
Website: <http://www.kb-omo.by>

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State Scientific Institution “Joint Institute of Mechanical Engineering  
of the National Academy of Sciences of Belarus”

## DIAMOND-CONTAINING METAL-MATRIX COMPOSITE FOR MAGNETIC-ABRASIVE TREATMENT



Diamond-containing metal-matrix composite (DMMC) for magnetic abrasive processing:  
*a* – DMMC structure; *b* – abrasive “brush” from DMMC in magnetic field

### Development Description

Diamond-containing metal-matrix composite of instrumental purpose “iron-nanostructured impact diamond” is used in technologies of magnetic-abrasive surface treatment of various hard-to-process materials (metals and alloys, ceramics, glass, semiconductors, superhard materials) used in mechanical engineering, optics, microelectronics, nuclear engineering, tool production.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Corresponds to CIS analogues.

### Intellectual Property Protection

RB patent № 23541 (30.07.2021); RF patent № 2749789 (16.06.2021).

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State program “High-Tech Technologies and Engineering” for 2021–2025, subprogram 9.2 “Development in the production of new and high technologies”, task 16 “Develop effective superhard materials, tools based on them and create an engineering and service center”.

### Field of Application

Mechanical engineering.

### Contact Information of Organization-Developer

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DEPARTMENT  
OF CHEMISTRY  
AND EARTH SCIENCES

State Scientific Institution "Institute of General and Inorganic Chemistry  
of the National Academy of Sciences of Belarus"

## ENGINEERING OF INTEGRATED TECHNOLOGY FOR PROCESSING OF POTASSIUM AND POLYMINERAL POTASSIUM ORES



### Development Description

Engineering of modern technological processes of potash and polymineral potash ores enrichment and processing. Engineering of flotation mode of ore preparation: ore desliming, flotation enrichment, sludge disposal; creation of fertilizers with improved agrochemical and physical-mechanical properties.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Technology development is carried out in accordance with customer requirements at the technological site of the Institute, which comprises equipment for ore preparation, flotation enrichment, halurgical processing, condensation and dehydration, drying and granulation of the final product, ore samples analysis. The productivity of technological equipment (for raw materials) is 1–2 tons/hour. The Institute's task is to justify the use of known

approaches to a specific ore composition from the point of view of chemical processes and economic feasibility and propose a technology with specific stages of ore processing. Currently, the Institute is the only organization in the country capable of resolving issues of this level.

#### Intellectual Property Protection

3 patents of the Republic of Belarus, 2 patents of Eurasian Patent Organization, patent EPO.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Foreign customer contracts were completed in 2012–2023.

#### Field of Application

Mining and chemical industry.

#### Contact Information of Organization-Developer

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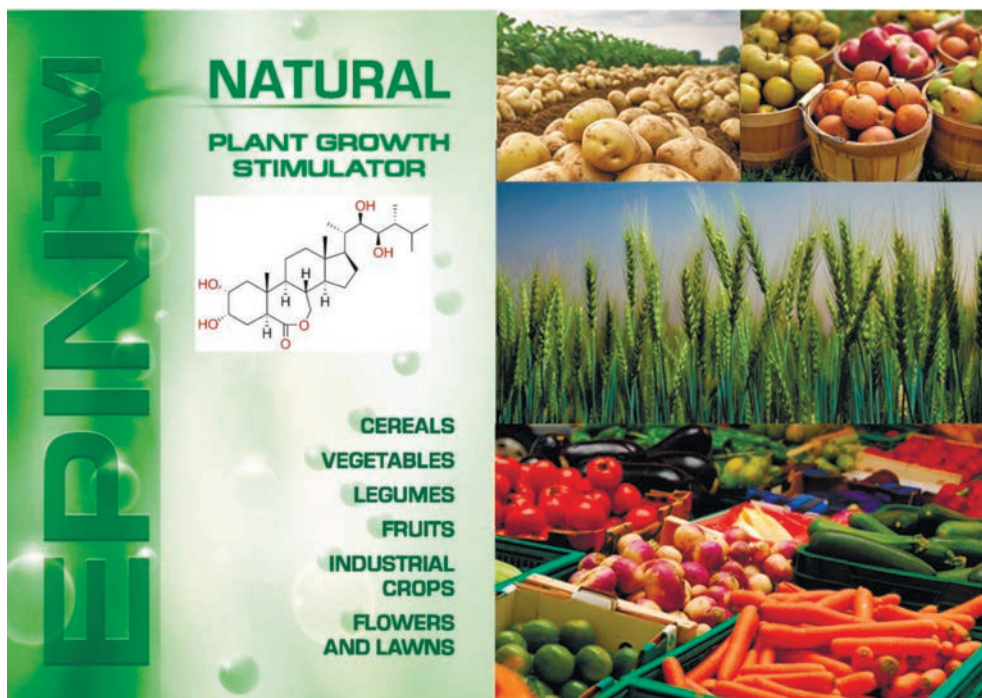
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State Scientific Institution "Institute of Bioorganic Chemistry  
of the National Academy of Sciences of Belarus"

## PLANT GROWTH REGULATOR



### Development Description

Epin is a plant growth and development regulator. The active ingredient of Epin is epibrassinolide – a phytohormone of natural origin belonging to the brassinosteroids class (BS) and is a natural component of all plants and food products of plant origin. Epin is intended to increase crop yields and improve product quality. The preparation increases the resistance of plants to diseases and pests, extreme temperatures, drought, soil salinity; improves root and fruit formation; reduces the fall of ovaries; promotes the accumulation of useful substances in products (starch, sugars, proteins); reduces the accumulation of nitrates, radionuclides, heavy metal salts, accelerates seed germination. Epin is environmentally safe, non-toxic to humans, animals, bees, beneficial insects, and fish.

The effect is available for all crops. Characteristic features of Epin application: the possibility of partial replacement of traditional pesticides, reducing their negative effects on plants and the environment; increasing the efficiency of assimilation of mineral fertilizers; achieving the effect by stimulating the natural defences of the plant; exceptionally low effective doses,



comparable to the natural content of the hormone in plants. It is authorised for use in the cultivation of cereals and legumes (winter rye, spring and winter wheat, spring barley, fiber flax, lupine, soybeans, etc.), vegetables (potatoes, table and sugar beets, carrots, cabbage, open and protected ground tomatoes, open and protected ground cucumber, radish, etc.), fruit, industrial crops, ornamental and flower plants.

It is included in the State Register of Plant Protection Products and Fertilizers approved for use on the territory of the Republic of Belarus (state registration dated January 24, 2020 No. 10-0022), TS RB 100185129.048-2002 (Amendment No. 4).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no domestic analogues. Corresponds to the best foreign analogues, being cheaper than they are.

#### Intellectual Property Protection

Preparation "Epin". Patents of the Republic of Belarus: No. 2806; 3488, 3400, 4342, 5168, 5212, 5698, 22409, patent of the Republic of Moldova No. 701, patent of the Russian Federation No. 2160000, Eurasian patents No. 013002 and 022248.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program "Chemical technologies and materials", 2016–2020; subprogram 2.3 "Plant bioregulators"; task 3.22 "Brassinosteroid-pesticide compositions as an innovative tool for managing plant productivity and resistance: study of the relationship "hormonal structure – activity"; State Program "Knowledge-intensive technologies and equipment", 2021–2025; subprogram 5 "Chemical products and molecular technologies"; task 2 "Develop technology and organize the production of the biological product "Epibrassinolide" using the green chemistry strategy".

#### Field of Application

Agricultural sector, veterinary medicine.

#### Contact Information of Organization-Developer

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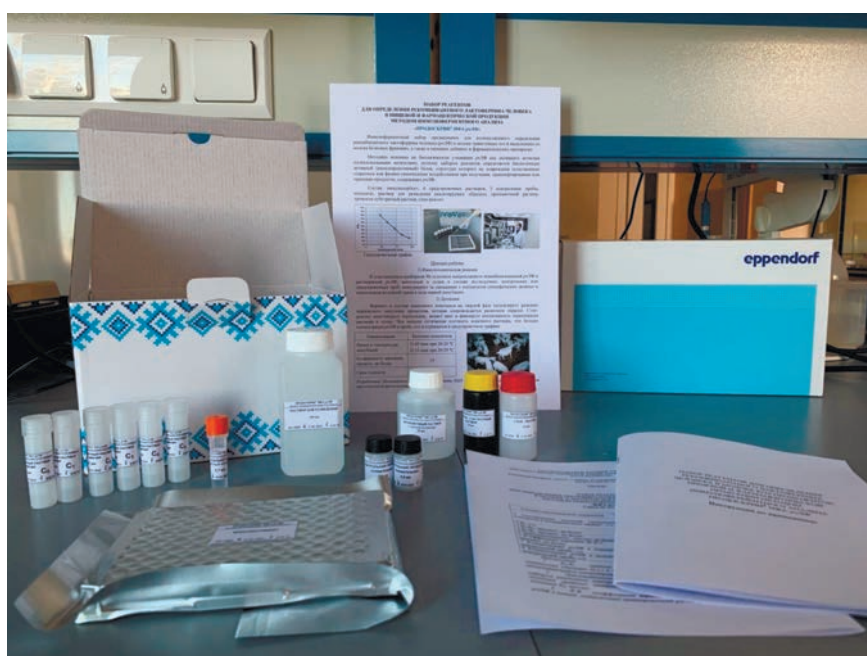
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State Scientific Institution "Institute of Bioorganic Chemistry  
of the National Academy of Sciences of Belarus"

## ENZYME IMMUNOASSAY KIT FOR THE DETERMINATION OF RECOMBINANT HUMAN LACTOFERRIN IN THE MILK OF GOATS-PRODUCERS, AND FOOD AND PHARMACEUTICAL PRODUCTS PRODOSCREEN® ELISA-RHLF



### Development Description

Recombinant human lactoferrin (rhLF) is a product identical to the natural human protein which is isolated in its pure form from milk of transgenic goats. rhLF has an amazing variety of biological activities and protective properties needed by children and beneficial for adults. To monitor rhLF production in animals and control its content in biologically active food supplements and pharmaceuticals it is necessary to quantify rhLF in various food and medicinal matrices. This purpose is achieved by the use of the enzyme immunoassay kit which is manufactured according to a full production cycle developed and mastered in Belarus. Its PRODOSCREEN® trademark is registered in the Republic of Belarus and the Russian Federation.

The analytical technique is based on the biological recognition of rhLF as a native antigen by polyclonal antibodies, therefore, PRODOSCREEN® ELISA-rhLF kit determines a biologically active (immunoreactive) protein whose structure is not damaged by natural ageing or physicochemical effects during production, transportation or storage of rhLF containing products. PRODOSCREEN® ELISA-rhLF kit allows testing up to 96 unknown and standard samples within 1.5 hours and determines with high parameters of accuracy and precision rhLF concentration in the range of 0.4–32.4 mg/l.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no full analogues of PRODOSCREEN® ELISA-rhLF kit. Known laboratory immunoassay systems or commercial reagent kits are based on natural human or cattle lactoferrin and intended for lactoferrin determination in human physiological fluids or cow's milk products.

#### Intellectual Property Protection

The subject of the intellectual property is the technology for the production of PRODOSCREEN® ELISA-rhLF kit. This technology is protected by the Institute of Bioorganic Chemistry of the National Academy of Sciences of Belarus as a trade secret.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program "Knowledge-intensive technologies and equipment", 2016–2020; subprogram 8 "Import-substituting diagnostics and biological products – 2020"; task 21 "Develop and master a method for enzyme immunoassay of lactoferrin in food and biotechnological products, a design and manufacturing technology for a reagent kit for performing the methodology" (co-executing organization – Institute of Meat and Dairy Industry, National Academy of Sciences of Belarus).

#### Field of Application

Animal husbandry, biotechnology, medicine, veterinary medicine, food industry, pharmaceutical industry, standardization metrology, food certification.

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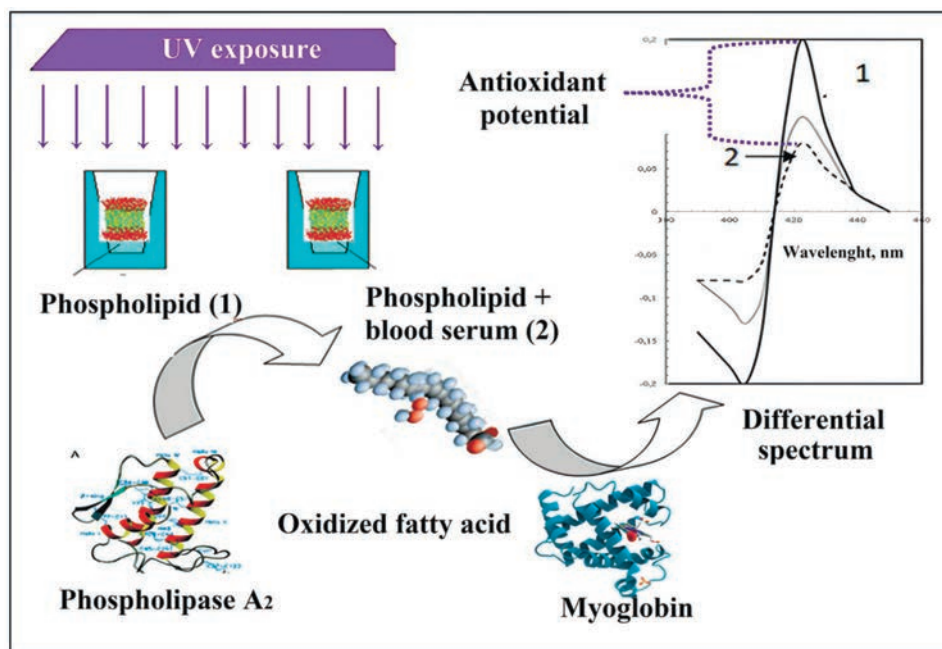
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State Scientific Institution "Institute of Bioorganic Chemistry  
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## UNIVERSAL ANTIOXIDANT POTENTIAL INDICATOR FOR DIAGNOSTICS OF HUMAN SUSTAINABILITY TO OXIDATIVE STRESS



### Development Description

The methodological basis for determination of human sustainability to oxidative stress on the rapid and effective total antioxidant capacity estimation in biological fluid has been created. The elaborating test-system uses lipid phase and hemoprotein as indicator. The test-system is comparable with kits for TAC and antioxidant status determination, based on estimation of hydrophilic moiety of the biological fluids on quantity, quality, diagnostic and labor costs parameters, but uses the estimation of oxidation degree in lipid phase, employing phospholipase A<sub>2</sub> and hemoprotein as lipolysis indicator.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The kit advantage compared with analogue test-systems is a fundamentally new approach to estimation of primary peroxide oxidation products of

phospholipids directly in lipid phase compound. There are no analogues in the world practice.

#### Intellectual Property Protection

It is the methodological basis of the test system. Patents of the Republic of Belarus Nos. 19669, 19670.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Chemical technologies and materials”; sub-program “Biologically active compounds”, 2016–2020; task 2.21. “Connection of phospholipids with biochemical defense systems under pathological conditions of organism”.

#### Field of Application

Scientific investigations, medicine.

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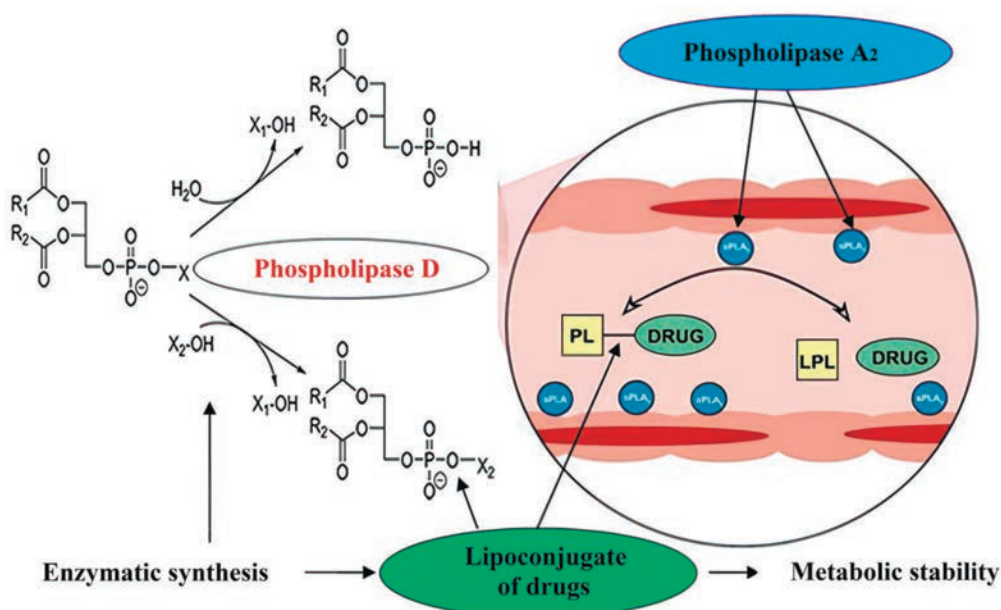
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State Scientific Institution "Institute of Bioorganic Chemistry  
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## ENZYMATIC SYNTHESIS OF LIPONUCLEOTIDS AND DETERMINATION OF THEIR RESISTANCE TO PANCREATIC PHOSPHOLIPASE A<sub>2</sub> ACTION (LIPOLYSIS)



### Development Description

The way of therapeutic efficacy enhancement of nucleoside remedies was developed: the synthesis of conjugates of nucleosides with phospholipids capable to resist the destruction under the pancreatic phospholipases hydrolysis. The phospholipid "anchor" promotes penetration of biologically active nucleoside to the cell membrane. Liponucleosides are entirely associated with internal environment of human organism and deliver the drug compounds to different cells, including arduous body parts, such as lymph nodes. Being modified phospholipids these conjugates appear to be the effectors of the metabolic enzymes, mainly those of phospholipolysis. The first stage of these compounds transformations in human organism is the cleavage of the conjugate molecule under action of pancreatic phospholipase A<sub>2</sub> (PLA<sub>2</sub>, EC number 3.1.1.4) during gestation or under activation nearby the tumor cell, where the mentioned enzyme acts either.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The advantage of this way of delivery compared with analogues in case of standard preparative forms is a principally new approach to activation of phospholipid conjugate within lipid phase in a given place. There are no analogues in the world practice.

**Intellectual Property Protection**

The way of therapeutic efficacy enhancement of nucleoside remedies. Patent of the Republic of Belarus No. 23571.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Project of the National Academy of Sciences of Belarus No. 116-12-03-2019, 2019–2020.

**Field of Application**

Scientific investigations, medicine.

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State Scientific Institution "Institute of Bioorganic Chemistry  
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## "PLA<sub>2</sub>-PDA" ASSAY KIT FOR PANCREATITIS DETECTION



### Development Description

The Kit is intended for the early differential diagnostics of severe necrotizing pancreatitis forms on the basis of rapid and effective determination of phospholipase A<sub>2</sub> activity, as the main diagnostic attribute of pancreas inflammation, in human blood serum by photometrical analysis. On quantity, quality, diagnostic, and labor costs parameters the kit is comparable with those based on amylase determination (although the amylase activity is not primary pancreatitis marker) currently used in clinical practice and procured abroad.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The advantage of this kit compared with import test-systems is 100 % diagnostic specificity, 3-times prolonged shelf-life of marker susceptibility, and lower cost for Belarusian consumer (the kit is 4–5 times cheaper than non-specific import amylase test systems). There are no analogues in the world practice.

### Intellectual Property Protection

"PLA<sub>2</sub>-PDA" Assay Kit for pancreatitis detection. Patents of the Republic of Belarus No. 12552, 13143.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program for the development of import-substituting production of pharmaceutical substances, finished medicinal and diagnostic products in the Republic of Belarus for 2010–2014 and til 2020. (Import-substituting pharmaceutical products), subprogram “Diagnosticums”, task D21 “Elaboration and approbation of a new biochemical test-system for detection of inflammation processes in gastrointestinal tract by photometric determination of pancreatic phospholipase A<sub>2</sub> activity in blood”.

**Field of Application**

Scientific research, medicine.

**Contact Information of Organization-Developer**

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State Scientific Institution "Institute of Bioorganic Chemistry  
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## COMPLEX OF THREE ENZYME IMMUNOASSAY SYSTEMS FOR DETERMINATION OF ANTIBIOTICS IN FOODSTUFFS



### Development Description

A complex of three enzyme-linked immunosorbent test systems for the quantitative determination of the antibiotics chloramphenicol, streptomycin, and bacitracin in a variety of food matrices. It is designed to control biosafety and quality of food raw materials and foodstuffs. It allows the determination of residual amounts of antibiotics in foodstuffs. These residues, when exceeding the legally established maximum permissible levels (MPL), can affect vital systems of the human body and contribute to the spread of pathogenic bacteria resistant to these drugs. The test systems are manufactured according to a full production cycle developed and mastered in Belarus. Their trademark PRODOSCREEN® is registered in the Republic of Belarus and the Russian Federation.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Test systems PRODOSCREEN® Chloramphenicol, PRODOSCREEN® Streptomycin, and PRODOSCREEN® ELISA-Bacitracin correspond to the best world analogues (Germany) by their scientific and technical level of their designs, analytical parameters, and performance characteristics. Certified methods for performing measurements using the test systems are included in the List of Standards, the application of which ensures compliance with the requirements of the technical regulations of the Customs Union

TR CU 021/2011, TR CU 033/2013, TR CU 034/2013 and the Eurasian Economic Union TR EAEU 040/2016. The developed test systems provide sensitive determination of antibiotics in accordance with hygienic requirements for the safety of food products and raw materials in terms of MPLs and are characterized by high specificity of analysis and reproducibility of measurement results in the concentration ranges of chloramphenicol (0.025–0.75 µg/l), streptomycin (0.5–40.5 µg/l) and bacitracin (0.5–27.5 µg/l) for milk and dairy products, meat and meat-containing products, fish, eggs, honey.

#### Intellectual Property Protection

Technologies are protected as trade secrets.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained:**

– Immunoassay system “PRODOSCREEN® Chloramphenicol”– State Research Program “Chemical Technologies and Materials”, 2016–2020; subprogram 2 “Biologically active substances”, task 17 “Chemical synthesis, biotechnological methods of preparation and study of interactions of derivatives of small biomolecules and proteins in immunoanalytical and biochemical systems”.

– Immunoassay system “PRODOSCREEN® Streptomycin”– State Program “Knowledge-intensive technologies and equipment”, 2016–2020; subprogram 1 “Innovative biotechnologies – 2020”; task 44 “Develop and implement a new design and production technology for a reagent kit for the determination of streptomycin in products of animal origin using an enzyme immunoassay method”.

– Immunoassay system “PRODOSCREEN® ELISA-Bacitracin”– State Program “Knowledge-intensive technologies and equipment”, 2016–2020; subprogram 8 “Import-substituting diagnostics and biological products – 2020”; task 13 “Develop and master the technology for the production and use of an enzyme immunoassay reagent kit for determining residual quantities of bacitracin in products of animal origin”.

#### Field of Application

Biotechnology, food industry, veterinary medicine, agriculture, sanitary and hygienic monitoring of raw materials and food.

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State Scientific Institution "Institute of Bioorganic Chemistry  
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## COMPLEX OF SIX ENZYME IMMUNOASSAY KITS FOR DETERMINATION OF MYCOTOXINS IN FOOD AND FEED



### Development Description

A complex of six enzyme-linked immunosorbent kits for the quantitative determination of the main mycotoxins - zearalenone, aflatoxin B1, T2 toxin, group B fumonisins, ochratoxin A and deoxynivalenol in grains, legumes and oilseeds and their processed products. It is designed to control bio-safety and quality of agricultural, feed industry, and food industry products. The complex allows the quantification of mycotoxins that are produced by mold fungi during the cultivation and storage of grain crops and as a result contaminate feed or foodstuffs. These contaminants, when exceeding the legally established maximum permissible level (MPL), can affect the vital systems of the human and animal body and lead to diseases, as well as cause reduction in the productivity of farm animals. The kits are manufactured according to a full production cycle developed and mastered in Belarus, having the status of import-substituting products under PRODO-SCREEN® trademark registered in the Republic of Belarus and the Russian Federation.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Immunoenzyme kits correspond to the best world analogues (Germany) by their scientific and technical level of their designs, analytical parameters,



and performance characteristics. Certified methods for performing measurements using the kits are included in the List of Standards the use of which ensures compliance with the requirements of the technical regulations of the Customs Union “On the safety of foodstuffs” (TR CU 021/2011). The developed kits allow sensitive determination of a variety of mycotoxins in a wide range of food and feed matrices in accordance with hygienic requirements for the safety of food products and raw materials in terms of MPLs and are characterized by high specificity of analysis and reproducibility of measurement results in the concentration range of zearalenone (50–800 µg/kg), aflatoxin B1 (2–50 µg/kg), T2 toxin (30–1000 µg/kg), group B fumonisins (110–6000 µg/kg), ochratoxin A (5–375 µg/kg) and deoxynivalenol (200–6000 mcg/kg).

#### Intellectual Property Protection

Technologies are protected as trade secrets.

Name of the programme, subprogramme, project, business contracts under which the development was obtained

– Kits PRODOSCREEN® ELISA-ZEARALENONE, ELISA-AFLATOXIN, ELISA-T2 TOXIN, ELISA-FUMONISIN B – State Program “Innovative Biotechnologies”, 2010–2012 and till 2015; subprogram “Agricultural Biotechnology (Livestock)”; task 1 “Creation of test system designs, technology development and organization of small-scale production of a complex of reagent kits for the enzyme-linked immunosorbent determination of mycotoxins in animal feed, and food products and food raw materials”.

– Kits PRODOSCREEN® ELISA-OCCHRATOXIN A and ELISA-DESOXINIVALENOL – State Scientific-Technical Program “Industrial Bio- and Nanotechnologies – 2020”, 2016–2020; task 407 “Develop and implement technologies for the production of enzyme immunoassay kits for monitoring feed and food for the content of mycotoxins ochratoxin and deoxynivalenol”.

#### Field of Application

Biotechnology, food industry, veterinary medicine, agriculture, sanitary and hygienic monitoring of raw materials and food.

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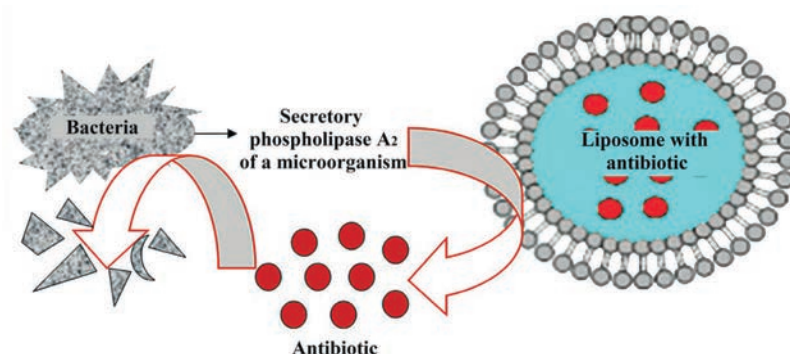
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State Scientific Institution "Institute of Bioorganic Chemistry  
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## LIPID-DEPENDENT REGULATION OF THE ACTIVITY OF SECRETORY PHOSPHOLIPASES IN MICROORGANISMS AS A NEW STRATEGY FOR INCREASING THE EFFECTIVENESS OF ANTIMICROBIAL DRUGS



### Development Description

A new approach to the creation of highly specific preparative forms of antimicrobial drugs is proposed by incorporating an antibiotic in the internal space of phospholipid nanocontainers of a given composition to solve problems that limit the use of many drugs (low solubility, biodegradability, side effects, toxicity). Modification of antimicrobial compounds using phospholipids, including in the form of mixed micelles, liposomes, and conjugates facilitates the penetration of drugs through the membrane, increases the targeted effect of the drug, provides the possibility of targeted delivery to the target, and reduces toxicity. The increase in the specificity of antimicrobial drugs is achieved by creating improved formulations due to the inclusion of an antibiotic in the internal space of nanocontainers of a given composition, which can be activated directly near the target cell due to their own phospholipolytic enzymes, acting as virulence factors.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed preparative forms correspond to the world's best analogues of drugs created on the basis of liposomes by their scientific and technical level of designs and use.

Their advantage is the use of the innovative approach that has no analogues in the world – specific activation directly near a given cell thanks to the phospholipolytic enzymes of the pathogenic microorganism itself, acting as virulence factors.

#### Intellectual Property Protection

The subject of intellectual property is the technologies for the production of nanocontainers of a given composition, the protection of which is carried out by the Institute of Bioorganic Chemistry of the National Academy of Sciences of Belarus as a trade secret.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Chemical processes, reagents and technologies, bioregulators and bioorgchemistry”, 2021–2025; subprogram “Chemical bases of life processes” (Bioorgchemistry); task 2.3.8 “Lipid-dependent regulation of the activity of secretory phospholipases of microorganisms as a new strategy for increasing the effectiveness of antimicrobial drugs”, state registration number 20210848, level of development – “world-class”.

#### Field of Application

Biotechnology industry, veterinary medicine, medicine.

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State Scientific Institution "Institute of Bioorganic Chemistry  
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## EPIBRASSINOLIDE BIOPREPARATION TECHNOLOGY USING GREEN CHEMISTRY STRATEGY



### Development Description

Epibrassinolide is a phytohormone of natural origin, belonging to the class of brassinosteroids, is a natural component of all plants and food-stuffs of plant origin. It is the active ingredient of Epin, which is intended to increase crop yields and improve product quality. The drug increases the resistance of plants to diseases and pests, extreme temperatures, drought, soil salinity; improves root and fruit formation; reduces falling ovaries; promotes the accumulation of nutrients (starch, sugars, proteins) in products; reduces the accumulation of nitrates, radionuclides, salts of heavy metals, accelerates seed germination. Epin is environmentally friendly, not toxic to humans, animals, bees, beneficial insects, fish.

Approved for cultivation of cereals and grain legumes (winter rye, spring and winter wheat, spring barley, flax, lupine, soybeans, etc.), vegetables (potatoes, table and sugar beets, carrots, cabbage, tomatoes in open and

protected soil, cucumbers in open and protected soil, radish, etc.), fruit, industrial crops, decorative, and flower plants.

The developed cyclic modular technology for obtaining the Epibrassinolide biopreparation from ergosterol includes 7 chemical and 99 technological stages, which combines the most effective methods for implementing all stages of the process.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Development provides the possibility of using inexpensive initial substances, reagents and solvents, as well as the possibility of their regeneration to increase environmental friendliness and economy of Epibrassinolide biological preparation production. The scientific and technical level of the Epibrassinolide biological product corresponds to the indicators of the world's best analogues. The cost of a domestic biological product is 2–10 times lower than the cost of the best imported analogues.

**Intellectual Property Protection**

Know-how is protected by the introduction of a trade secret regime.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SP “High-Tech Technologies and Engineering” for 2021–2025, subprogram 5 “Chemical products and molecular technologies”, task 2 “Develop a technology and organize the production of Epibrassinolide biologics using a green chemistry strategy”.

**Field of Application**

Agriculture.

**Contact Information of Organization-Developer**

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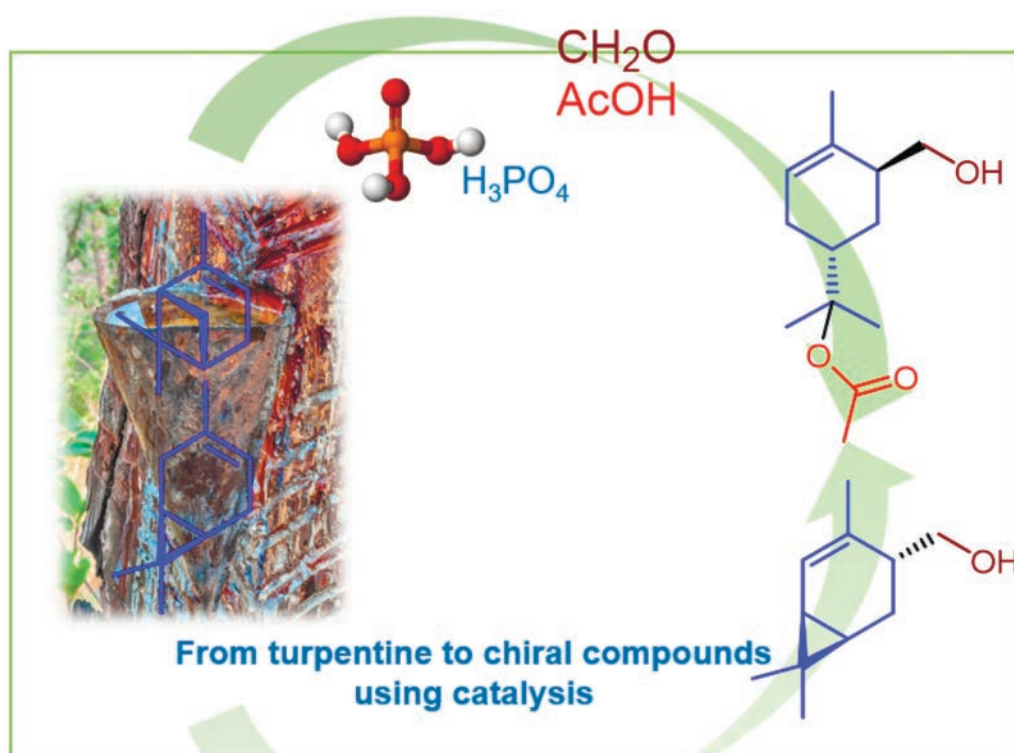
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State Scientific Institution "Institute of Chemistry of New Materials  
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## NEW PROCESSES FOR CATALYTIC PROCESSING OF HYDROCARBONS TURPENESS



### Development Description

A fundamentally novel approach has been developed for the utilization of the renewable hydrocarbon  $\alpha$ -pinene (the main component of turpentine) by its catalytic condensation with formaldehyde into a previously undescribed terpenoid 8-acetoxy-6-hydroxymethyllimonene. It has been shown that when the  $\text{H}_3\text{PO}_4$ -AcOH catalytic system is used, the contribution of side reactions (isomerization, Wagner-Meerwein rearrangement) is minimal, which provides the largest selectivity for the target product. The reaction mechanism and pathways are discussed using kinetic and quantum chemical calculations. 8-Acetoxy-6-hydroxymethyllimonene can be considered as a new chiral platform for further synthesis, including compounds with pharmaceutical potential. An efficient one-step method



for the catalytic synthesis of 4-hydroxymethyl-2-carene (a commercially important fragrant compound) from 3-carene has been created. Although selectivity for the target product is limited by secondary reactions (acetylation, cyclization), its yield increases significantly with increasing amount of formaldehyde and catalyst ( $\text{H}_3\text{PO}_4$ ) concentration, reaching ~70 %. The reaction mechanism is proposed and discussed in detail. The synthesis of 4-hydroxymethyl-2-carene was carried out on a scale of up to 25 g, and the possibility of recycling 3-carene was shown. Developed jointly with the Novosibirsk Institute of Organic Chemistry of the Siberian Branch of the Russian Academy of Sciences.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

A new process for processing  $\alpha$ -pinene in the presence of the  $\text{H}_3\text{PO}_4$ -AcOH catalytic system makes it possible to obtain 8-acetoxy-6-hydroxymethylimonene. It is a new chiral platform (building block) for further synthesis. An effective method for the preparation of 4-hydroxymethyl-2-carene from 3-carene allows the synthesis of this aromatic compound in one step on a simple catalyst ( $\text{H}_3\text{PO}_4$ ) with a selectivity of up to 70 %, which is higher than with known analogues. The development has no analogues in the world.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Agreement X23RNF-028 "Development of catalytic systems for the selective synthesis of new chiral biologically active heterocyclic compounds based on monoterpenes" jointly with the Novosibirsk Institute of Organic Chemistry SB RAS (2022–2025).

Field of Application

Fine synthesis, laboratory synthesis, scientific research, enterprises of the wood chemical and pharmaceutical industries.

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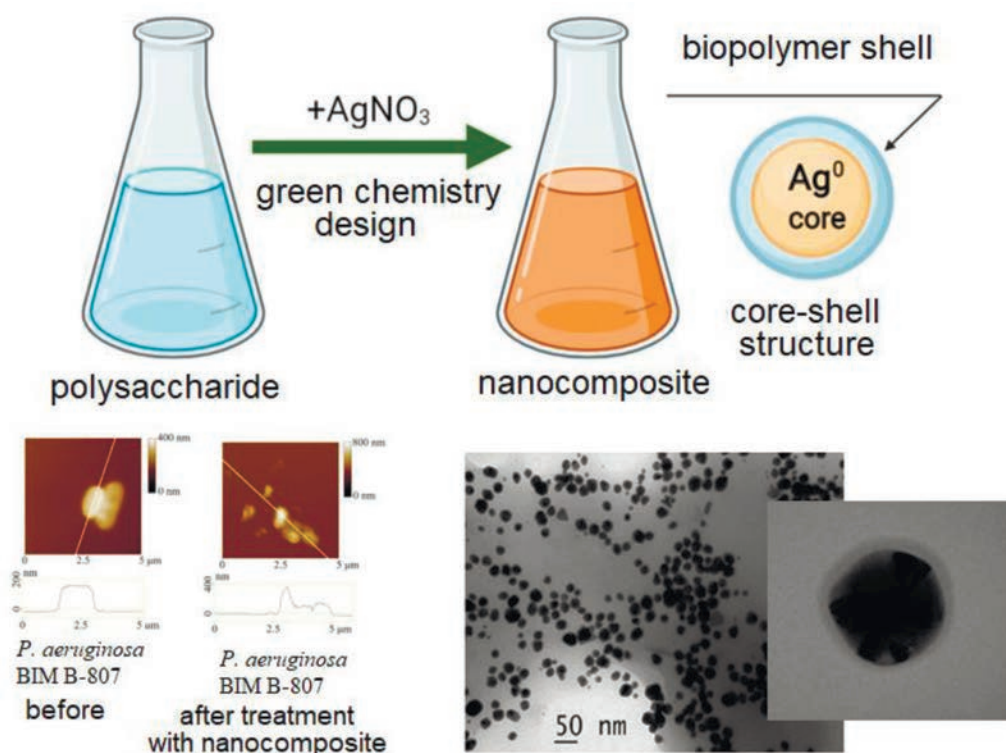
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State Scientific Institution "Institute of Chemistry of New Materials  
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## ANTIBACTERIAL POLYSACCHARIDE-SILVER NANOCOMPOSITES



### Development Description

Colloidal solutions and lyophilized powders of biocompatible, non-toxic polysaccharide-Ag nanocomposites with controlled physical-chemical and biological properties. Pectins, alginates and chitosans are used as biopolymer components. Nanocomposites have an enhanced antibacterial effect against bacterial strains collected and isolated from sick organisms.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Polysaccharide-Ag nanocomposites are synthesized using green chemistry approaches, using the reducing and stabilizing potential of polysaccharides (pectin, chitosan, alginate) isolated from renewable raw materials. They have a pronounced antibacterial effect against gram-positive and gram-negative bacteria. Moreover, their antibacterial effect is due to

the ability to destroy the cell walls of bacteria. According to the parameters of acute intragastric and inhalation toxicity, they belong to low-hazard substances (hazard class 4), according to the parameters of intraperitoneal toxicity to practically non-toxic/harmless substances (hazard class 5 according to the classification of Sidorov K. K.), they are non-irritating to the skin, resorptive and have a low effect when tested on animals.

Polysaccharide-Ag nanocomposites have additive and synergistic effects in combination with antibiotics, including activity against resistant strains. They can be used in the form of hydrosols, and can also be used to form modifying layers on medical products (for example, polypropylene surgical meshes) to protect them from bacteria. The development is world class and has no direct analogues.

#### Intellectual Property Protection

Patent BY 22469 C1 2019.04.30 Methods for obtaining hydrosols of pectin-Ag nanocomposite V. E. Agabekov, K. S. Hileuskaya, V. I. Kulikouskaya, A. N. Kraskouski, Muhanna K. A. Al-Muhanna.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

In 2023, the work was carried out within the framework of BRFFR grants: with Armenia X21ARM-001 “Synthesis of alginate-Ag hydrosols and development on their basis of new compositions with antibiotics for prevention and treatment aeromonosis and pseudomonosis in fish” (together with Yerevan State University, 2021–2023) and with Vietnam B21V-002/01 “Synthesis and study of the physicochemical characteristics of pectin-silver and chitosan silver nanocomposites” (together with the Institute of Experimental Botany NAS Belarus and the Institute of Chemistry of the Vietnam Academy of Science and Technology, 2021–2023).

#### Field of Application

Veterinary medicine, medicine, perfume and cosmetics industry, agriculture, wood chemical and pharmaceutical industries.

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DEPARTMENT  
OF BIOLOGICAL SCIENCES

State Scientific Institution “Institute of Biophysics and Cell Engineering  
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## BIOTECHNOLOGICAL COLLECTION OF CELL CULTURES



### Development Description

Collection of cell cultures of human, animal, higher plants, algae, and cyanobacteria which includes 127 cell cultures: 33 human cell cultures, 14 animal cell lines, 6 cyanobacteria strains, 34 algae strains, 35 callus cultures, and 5 suspension cultures of plant species.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The unique collection of high quality standardized sterile biological material for maintenance of in vitro scientific researches, evaluation of conditions and potential of accumulation biological active substances for food and pharmacological industry, selection and preservation of genetic material of valuable species and varieties.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Project of fundamental and applied research of the National Academy of Sciences of Belarus “Create a biotechnological collection of cell cultures of humans, animals, higher plants, algae and cyanobacteria for the purpose of depositing standardized cellular material for various sectors of the national economy”, 2019–2020.

### Field of Application

Medicine, pharmacology, agriculture.

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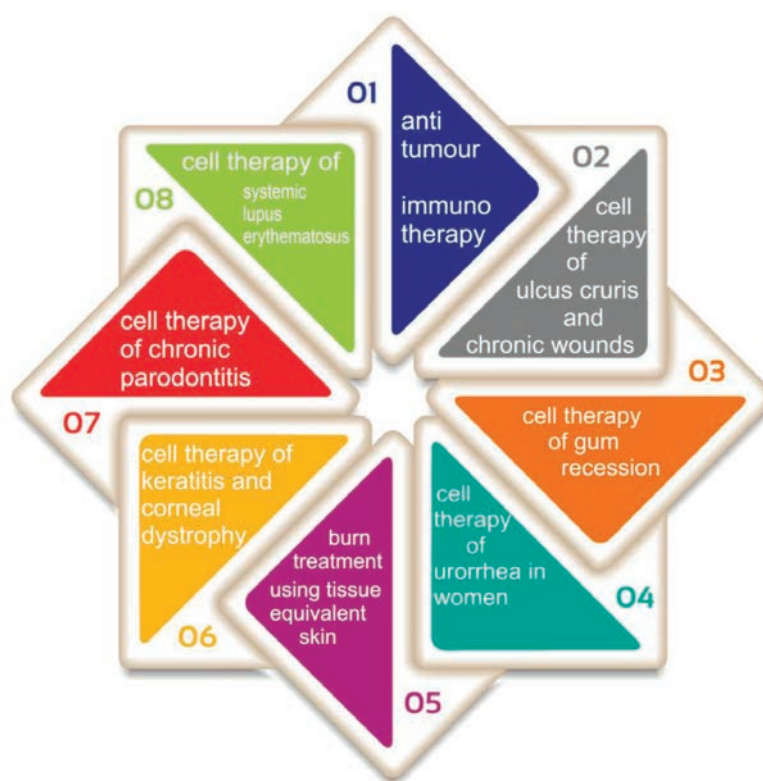
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## CELL TECHNOLOGIES FOR MEDICINE



### Development Description

The methods for medical treatment based on biomedical cell products (BMCP).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Unique technologies for the treatment and prevention of human diseases that are refractory to methods of conventional medicine:

- methods of cellular immunotherapy of oncological diseases using monocyte-derived dendritic cells make it possible to increase the relapse-free period and regulate the timing of subsequent lines of chemotherapy, stabilize the tumor process in 40–50 % of cases, with partial or complete regression (5–15 %), and reduce the risk metastasis;
- cellular therapy for keratitis and corneal dystrophies using autologous limbal stem cells and adipose-derived mesenchymal stem cells ensures

re-epithelialisation of the cornea and supports its long-term regenerative properties;

- method of cell therapy for systemic lupus erythematosus (SLE) using allogeneic pooled mesenchymal stem cells provides stable clinical remission and has a positive effect on the prognosis in patients with progressive SLE;

- method of cell therapy for gum recession using mesenchymal stem cells eliminates inflammation, neutralizes dystrophic changes in the gums, and prevents further destruction of periodontal tissue;

- method of cell therapy of chronic periodontitis using mesenchymal stem cells of adipose tissue, predifferentiated in the osteogenic direction, immobilized on a collagen membrane, stimulates the formation of new bone tissue, which allows increasing the width of the alveolar ridge and improving the possibilities for primary fixation of implants;

- method of cell therapy for female urocystitis using mesenchymal stem cells provides paracrine induction of synthetic processes in the paraurethral connective tissue and stimulation of regeneration of the muscular elements of the sphincter;

- methods of cell therapy for trophic ulcers and chronic wounds using mesenchymal stem cells and fibroblasts ensure healing of the wound defect with complete restoration of the skin;

- method of cell therapy for skin burns using skin tissue equivalent (TES), a multicomponent tissue-engineered structure consisting of cultured keratinocytes and fibroblasts, ensures the proliferation of epidermal and dermal cells, which leads to full-thickness regeneration of the skin wound.

#### Intellectual Property Protection:

IFU approved by the Ministry of Health of the Republic of Belarus:

- “Method for the treatment of systemic lupus erythematosus using a biomedical cell product based on allogeneic pooled mesenchymal stem cells of the olfactory lining” (registration No. 189-1220, 28.01.2021);

- “Method for the treatment of gum recession using a mixture of autologous mesenchymal stem cells of adipose tissue with collagen gel 7 %” (registration No. 048-0518, 01.06.2018);

- “Method for the treatment of chronic periodontitis using mesenchymal stem cells of adipose tissue induced to differentiate in the osteogenic direction” (registration No. 163-1220 dated, 24.12.2020);

- “Method for the treatment of uroclepsia in women using autologous mesenchymal stem cells of adipose tissue” (registration No. 172-1219, 26.12.2019);

- “Method of treating patients suffering from relapse of muscle-invasive bladder cancer using a biomedical cell product based on autologous dendritic cells” (registration No. 190-1220, 28.01.2021);



– “Method for the treatment of scars and age-related skin atrophy using a biomedical cell product of dermal fibroblast culture” (registration No. 017-0321, 31.03.2021).

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-end technology and engineering”, 2016–2020; tasks 28, 31, 32, 48, 49, 513.

**Field of Application**

Medicine: cell therapy of wide range of human disease in the field of surgery, rheumatology, stomatology, urology, traumatology, etc. Immune therapy of oncological and autoimmune diseases.

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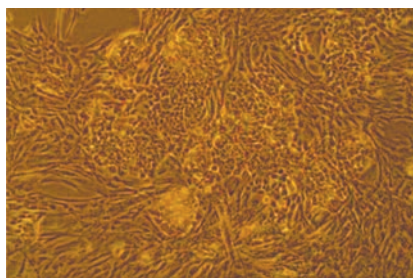
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State Scientific Institution “Institute of Biophysics and Cell Engineering  
of the National Academy of Sciences of Belarus”

## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR THE TREATMENT OF ALOPECIA



### Development Description

Innovative biomedical cell product was developed on the basis of hair follicle cells for alopecia treatment. Cell therapy using of the BMCP increase significantly hair follicle regeneration, rise effectiveness of the existing methods of alopecia treatment, decreasing treatment cost and increasing patients' life quality.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Corresponds to foreign analogues and has lower price. BMCP based on hair follicle cells will be import-substituting product for Belarus and export-oriented product.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

STATE Program “Science-based Technologies” for 2021–2025, subprogramme 1 “Innovative biotechnologies”, task 28 “Develop a biomedical cell product based on skin follicular stem cells”.

### Field of Application

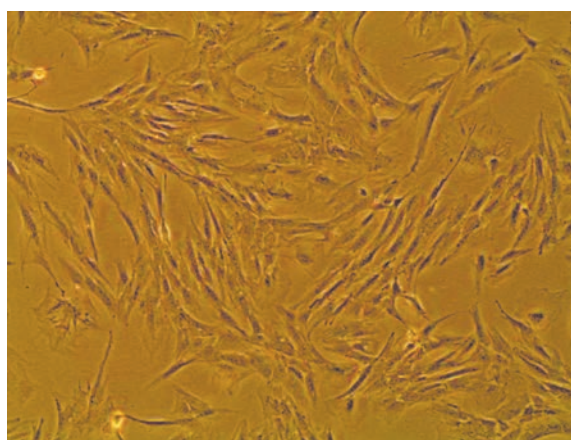
Dermatology, cosmetology, regenerative medicine.

### Contact Information of Organization-Developer

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State Scientific Institution "Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT WITH INCREASED RESTORATIVE CAPACITY



### Development Description

Innovative biomedical cell product (BMCP) was developed on the basis of cultivated mesenchymal stem cells enriched with extracellular vesicles (MSC-EV). MSC-EV BMCP is characterized by increased regenerative, angiogenic potential and anti-inflammatory activity for use in surgery, traumatology, and regenerative medicine. The enhanced properties of developed BMCP allow decreasing time of its production and price of the treatment. The application of MSC-EV BMCP will increase effectiveness of the existing treatment methods, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

MSC-EV BMCPs do not have competitors in the Republic of Belarus and is up there with foreign analogues. Advantages in comparison with foreign competitors are lower price of one dose of BMCP and treatment with it. Biomedical cell product based on cultivated mesenchymal stem cells enriched with extracellular vesicles will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 33 “Develop a technology for producing extracellular vesicles from mesenchymal stem cells with regenerative potential”.

**Field of Application**

Surgery, traumatology, regenerative medicine.

**Contact Information of Organization-Developer**

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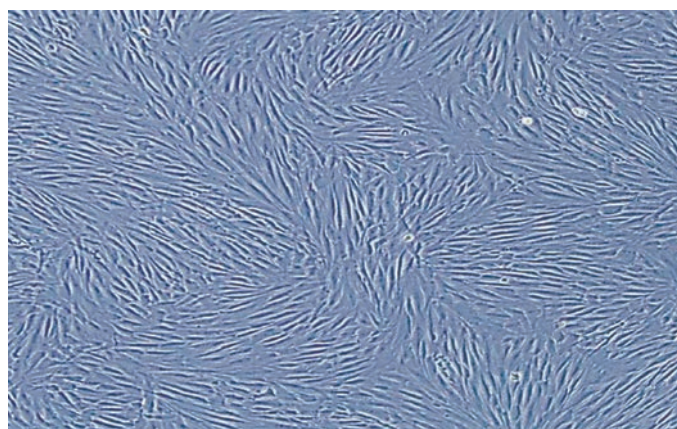
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State Scientific Institution "Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT WITH ENHANCED IMMUNOSUPPRESSIVE AND ANTI-INFLAMMATORY PROPERTIES FOR USE IN OTORHINOLARYNGOLOGY



### Development Description

Innovative biomedical cell product (BMCP) was developed on the basis of autologous and allogenic mesenchymal stem cells of olfactory lining (MSC OL) with enhanced immunosuppressive and anti-inflammatory properties for use in otorhinolaryngology. Cell therapy using MSC OL with enhanced immunosuppressive and anti-inflammatory properties in addition to standard treatment of chronic polypus rhinosinusitis (CPR) and allergic rhinitis (AR) improves the course of disease which is expressed in eliminating difficulties in nasal breathing, reducing the intensity and amount of nasal discharge, inflammation and the need to take medications. The application of developed BMCP will increase effectiveness of the existing treatment as a result of suppression of inflammation and stimulation of tissue regeneration, reduce treatment expenses, mince duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

BMCP MSC OL with enhanced immunosuppressive and anti-inflammatory properties do not have competitors in the Republic of Belarus and is

up there with foreign analogues. BMCP MSC OL with enhanced immunosuppressive and anti-inflammatory properties will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 25 (27) “Develop a biomedical cell product based on mesenchymal stem cells of the olfactory lining with improved immunosuppressive and anti-inflammatory properties”.

Field of Application: medicine, otorhinolaryngology.

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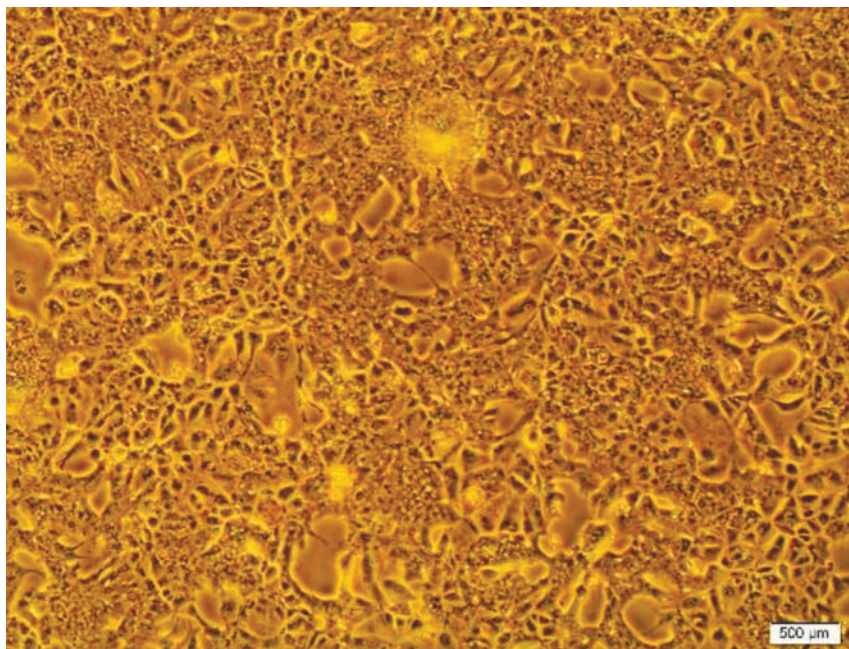
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State Scientific Institution "Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR THE TREATMENT PATIENTS WITH ACQUIRED HYPOPARATHYROIDISM



### Development Description

Innovative biomedical cell product (BMCP) based on parathyrocyte for the treatment of patients with acquired hypoparathyroidism. The cell therapy using BMCP aimed at correcting the level of parathyroid hormone in the blood of patients. The developed BMCP is characterized by high viability of parathyrocyte and can effectively reduce the need for calcium-containing medications. The application of the cell therapy will increase effectiveness of the existing treatment, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

BMCP based on parathyrocyte does not have the analogues in the Republic of Belarus and is up there with foreign analogues. Advantages in comparison with foreign competitors are lower price of one dose of BMCP

and treatment with it. Parathyrocyte-based BMCP will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 26.

**Field of Application**

Endocrinology, regenerative medicine.

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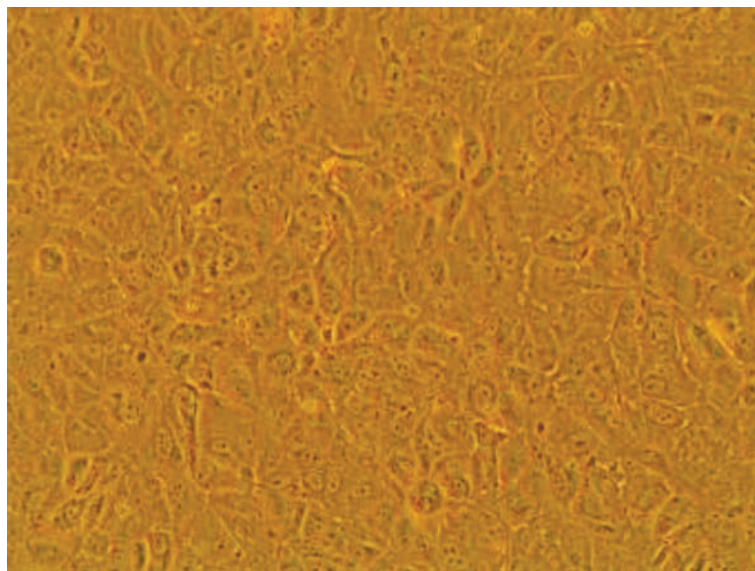
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## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR CELL THERAPY OF THE DEGENERATIVE DISEASES OF THE RETINA



### Development Description

Innovative biomedical cell product (BMCP) based on retinal pigment epithelium of the retina for treatment of retinal disease. The cell therapy of retinal disease using BMCP based on retinal pigment epithelium of the retina stimulates reparative process in retina increasing visual acuity. The application of cell therapy will increase the effectiveness of the existing treatment, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

BMCP based on retinal pigment epithelium of the retina does not have the competition in the Republic of Belarus and is up there with foreign analogues. Advantages in comparison with foreign competitors are lower price of one dose of BMCP and treatment with it. BMCP based on retinal pigment epithelium of the retina will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries

### Intellectual Property Protection

None.

Name of the programme, subprogramme, project, business contracts under which the development was obtained

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 37 “Develop a biomedical cell product based on retinal pigment epithelial cells”.

### Field of Application

Ophthalmology, regenerative medicine.

### Contact Information of Organization-Developer

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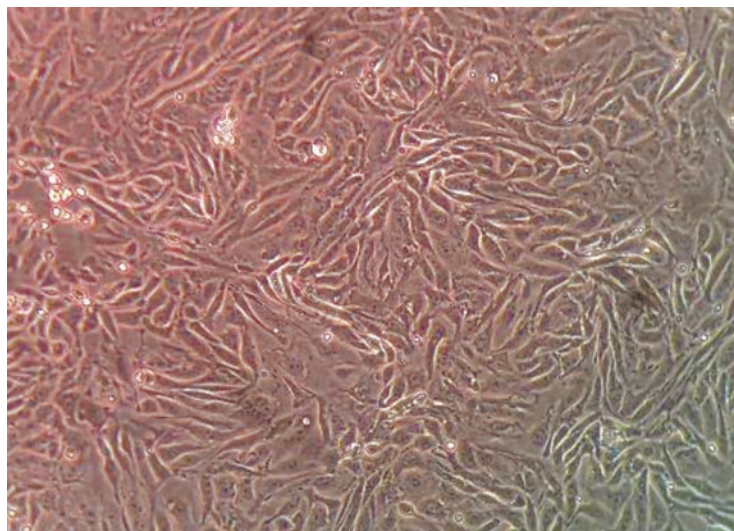
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State Scientific Institution “Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR THE USE IN CELL THERAPY OF DISEASES OF THE FEMALE REPRODUCTIVE SYSTEM



### Development Description

Innovative biomedical cell product (BMCP) based on cultivated mesenchymal stem cells capable of differentiation in the endometrial-decidual direction (edMSC) for the use in obstetrics and gynecology. The cell therapy using BMCP edMSC stimulates restoration of vascularization, receptor apparatus, thickness and architectonics of affected or thin endometrium. The application of BMCP edMSC will help to decrease the number of patients with miscarriage, increase effectiveness of extracorporal fertilization, reduce or cancel hormonal load in the treatment of dystrophic diseases of the endometrium. The application of cell therapy using BMCP edMSC will increase effectiveness of the existing treatment, duration of the event-free survival and patient's life, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

BMCP based on edMSC do not have the competition in the Republic of Belarus and is up there with foreign analogues. Advantages of edMSC in

comparison with foreign competitors are lower price of one dose of BMCP and treatment with it. BMCP based on cultivated mesenchymal stem cells capable of differentiation in the endometrial-decidual direction will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 27 “Develop biomedical cell product based on mesenchymal stem cells capable of differentiation in the endometrial-decidual direction”.

**Field of Application**

Gynecology, obstetrics, regenerative medicine.

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State Scientific Institution “Institute of Biophysics and Cell Engineering  
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## BIOMEDICAL CELL PRODUCTS



### Development Description

Biomedical cell products (BMCP) line based on mesenchymal stem cells, dendritic cells, limbal stem cells, fibroblasts, and keratinocytes.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Unique technologies for the production of biomedical cell products based on:

- mesenchymal stem cells from adipose tissue, bone marrow, and olfactory lining;
- pooled mesenchymal stem cells;
- mesenchymal stem cells predifferentiated in osteogenic direction;
- epithelial stem cells of cornea limbus;
- fibroblasts and keratinocytes;
- monocyte-derived dendritic cells.

### Intellectual Property Protection

State registration certificates:

“Mesenchymal stem cells”, 22.12.2020 No. BK7.2/7.0022008;

“Culture of human dermal fibroblasts”, 14.02.2019 No. БК7.61612;  
“Epithelial stem cells of cornea limbus”, 29.06.2020 No. БК7.91910;  
“Human tissue skin equivalent”, 29.06.2020 No. БК7.81910.  
“Dendritic cells”, 21.10.2022 No. БК7.122102.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-end technology and engineering”, 2016–2020; tasks 28, 31, 32, 48, 49, 51.

**Field of Application**

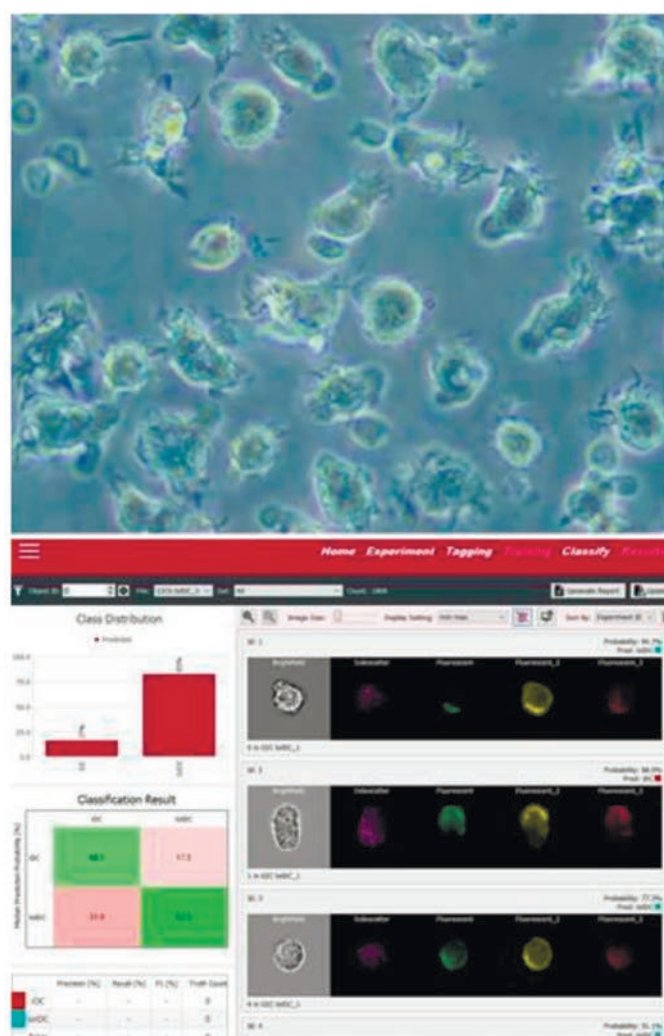
Medicine: cell therapy for a wide range of human disease in the field of surgery, rheumatology, stomatology, urology, traumatology, etc. Immune therapy of oncological and autoimmune diseases.

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State Scientific Institution “Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR THE TREATMENT OF TYPE 1 DIABETES MELLITUS



### Development Description

Innovative biomedical cell product (BMCP) based on tolerogenic dendritic cells (tolDC) for the treatment of type 1 diabetes mellitus. The cell therapy using BMCP tolDC slows down progression of type 1 diabetes mellitus, maintains the level of the C-peptide and daily dose of the insulin, suppresses processes of destruction of native  $\beta$ -cells of patient's pancreas. Application of cell therapy will increase effectiveness of the existing

treatment, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues

BMCP based on tolerogenic dendritic cells do not has the competition in the Republic of Belarus and is up there with foreign analogues. BMCP based on tolerogenic dendritic cells will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 23 “Develop biomedical cell product based on tolerogenic dendritic cells”.

Field of Application

Medicine.

Contact Information of Organization-Developer

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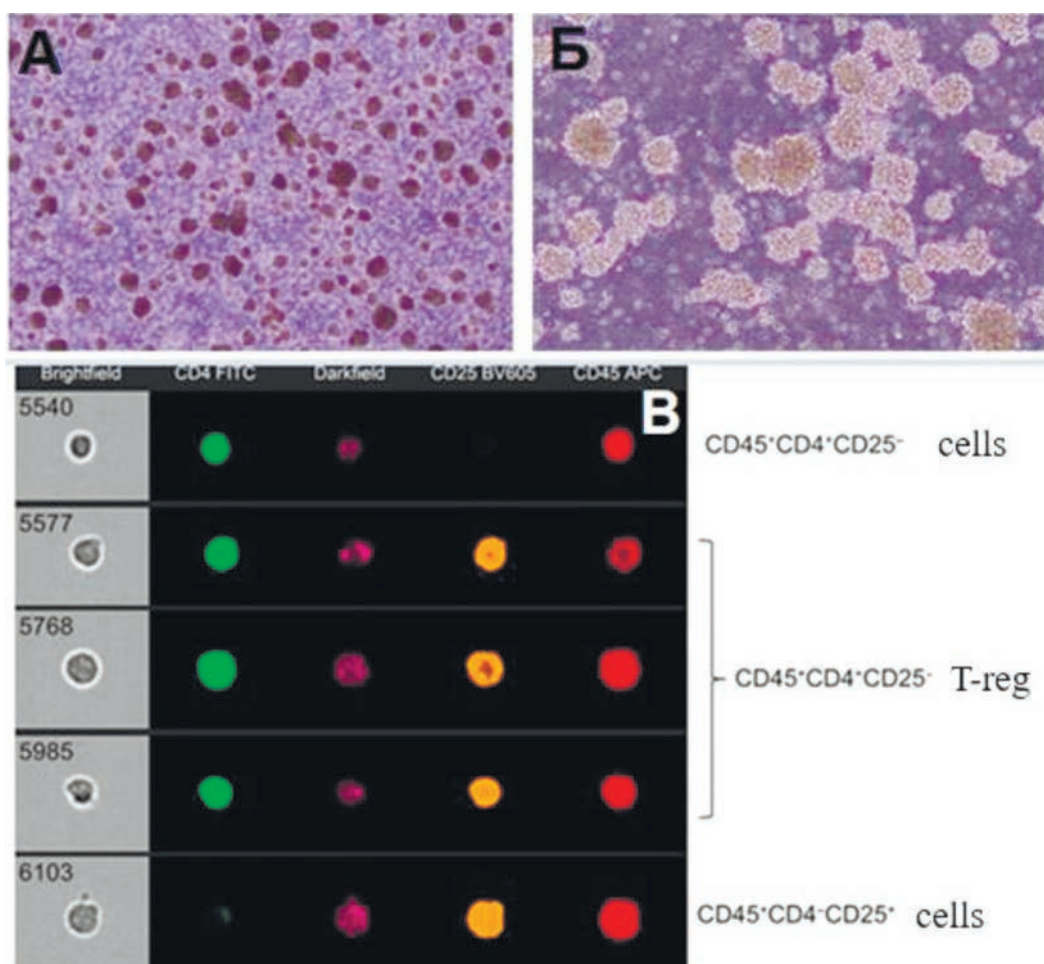
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State Scientific Institution "Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR THE TREATMENT OF SYSTEMIC SCLEROSIS



### Development Description

Innovative biomedical cell product (BMCP) based on autologous T-regulatory lymphocytes (T-reg) for the treatment of autoimmune disease – systemic sclerosis (SS). The cell therapy using BMCPT-reg decreases the incidence rate of visceral complications of SS compared to conventional treatments. The application of the cell therapy will increase effectiveness of the existing treatment, duration of the event-free survival and patient's life, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

BMCP based on T-reg do not have the competition in the Republic of Belarus and is up there with foreign analogues. BMCP based on T-regulatory lymphocytes will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 22 “Develop biomedical cell product based on T-regulatory lymphocytes”.

**Field of Application**

Medicine, rheumatology.

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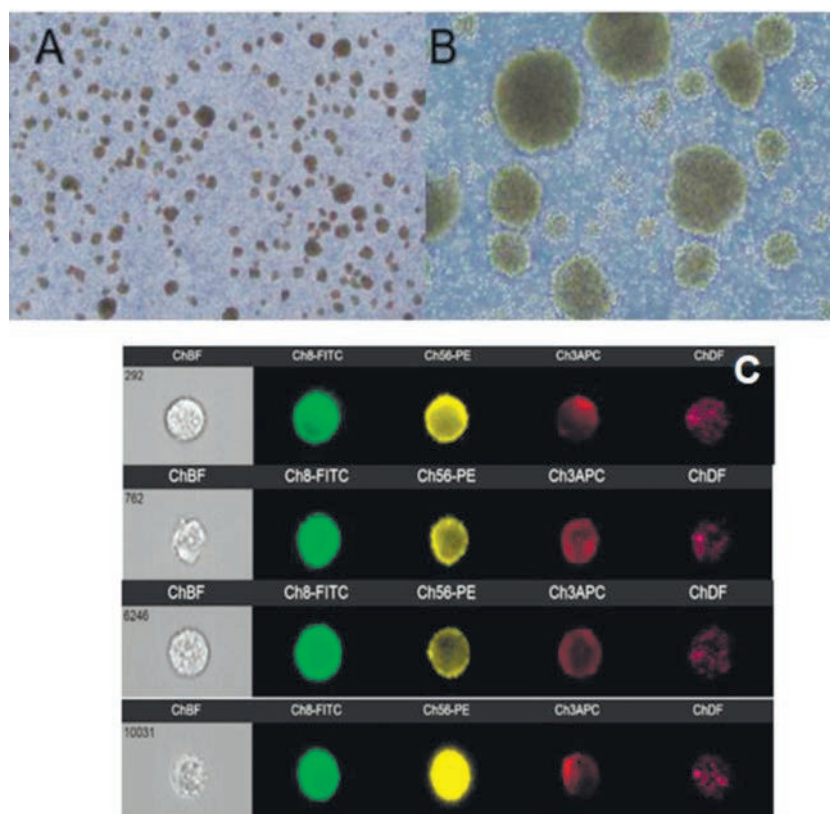
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State Scientific Institution “Institute of Biophysics and Cell Engineering  
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## INNOVATIVE BIOMEDICAL CELL PRODUCT FOR THE TREATMENT OF ONCOLOGICAL DISEASES (KIDNEY CANCER, BLADDER CANCER)



### Development Description

Innovative biomedical cell product (BMCP) based on autological cytokine-induced killer cells (CIKC) for the treatment of oncological diseases – recurrent and metastatic kidney cancer (KC) and also primary and recurrent muscle-invasive bladder cancer (PRMIBC). The cell therapy with the use of the BMCP CIKC allows to increase the event-free survival of patients during 10–12 months, decrease the risk of metastasis, amount of circulating tumor cells. The application of cell therapy using BMCP CIKC will increase effectiveness of the existing treatment, duration of the event-free survival and patient’s life, reduce treatment expenses, decrease the duration of hospitalization and losses from underutilization of labor resources.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

In the Republic of Belarus the development of treatment methods using BMCP CIKC has not been performed before. The developed biomedical cell product is significantly superior to known analogues. BMCP based on cytokine-induced killer cells will be import-substituting product for Belarus and export-oriented product for near and far-abroad countries.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based Technologies” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 24 “Develop biomedical cell product based on cytokine-induced killer cells”.

**Field of Application**

Medicine, oncology.

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State Scientific and Production Association "Scientific and Practical Center  
of the National Academy of Sciences of Belarus on Bioresources"

## SCIENTIFIC OBJECT "ZOOLOGICAL COLLECTION AND GENETIC BANK OF WILD FAUNA"



### Development Description

Systematic collection of reference specimens for species identification of invertebrates of the Republic and the region as a whole and samples of biological material of various typical representatives of wild fauna, collected taking into account their ecological-cenotic and population-chorological significance. The total fund of the Zoological Collection and the Genetic Bank of Wild Fauna is 1954 invertebrate specimens of 767 species taxa and 1672 samples of biomaterial of wild animals from 331 species. It performs the function of a scientific and reference information center for the accumulation, conservation and scientific use of biological and genetic material characterizing the faunal diversity of the animal world within Northern Eurasia with an emphasis on the territory of the Republic of Belarus. Contributes to the maintenance of the cadastre of the wildlife of Belarus, the preparation of national reports on the conservation of biodiversity and other international documents in the field of the protection and rational use of wildlife in accordance with the Convention on Biodiversity, the Cartagena Protocol on Biosafety, the Nagoya Protocol and allows the Republic of Belarus to occupy high positions in the field of studying the biological diversity of the planet, the development of animal taxonomy and other fundamental areas. In the Zoocollection and Genbank of wild fauna, information about the biological diversity of the ani-

mal world of our country and a significant part of the Palearctic region over a historically long period is concentrated, which is the basis for recording and building scenarios of animal dynamics under the influence of various anthropogenic factors and climate change, analysis of ways and terms of penetration of alien, including invasive species, and their effects on native fauna and ecological balance of local ecosystems. In the collections, among other things, there are specimens and samples of animal tissues from species that are currently very rare, included in the Red Book of the Republic of Belarus, are relics, extinct or endangered in many European countries, as well as collected in one or more copies over a century period.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no similar funds in Belarus. In terms of volume and representation of taxa of various groups of animals, it corresponds to the best collections in the world, including the collections of the Zoological Institute of the Russian Academy of Sciences (ZI RAS), the Institutes of Zoology of the NAS of Ukraine and the Polish Academy of Sciences in Warsaw. Collection collections are unique, allow assessing the faunal diversity of the animal world both within Belarus and Northern Eurasia.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

According to Decree of the Presidium of the National Academy of Sciences of Belarus No. 19 dated April 21, 2022, the Scientific Object is included in the State Register of Scientific Objects that Constitute a National Treasure. The functioning of the scientific object “Zoological Collection and Genetic Bank of Wild Fauna” is carried out in the prescribed manner at the expense of the republican budget of the Republic of Belarus, provided for scientific and scientific-technical activities.

**Field of Application**

Agriculture, medicine, forestry, education.

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State Scientific and Production Association “Scientific and Practical Center of the National Academy of Sciences of Belarus on Bioresources”

## SCIENTIFIC SUPPORT OF RED DEER SETTLEMENT IN HUNTING FARMS OF BELARUS



### Development Description

Biological substantiation of red deer introduction into hunting farms of Belarus, recommendations on biotechnical measures, selection of territory plots for red deer introduction.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Corresponds to the best domestic and foreign analogues, cheaper than the best domestic and foreign analogues.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

– State Program “Belarusian Forest” for 2016–2020, subprogram 3 “Development of hunting economy”, task 9 “Study of migration characteristics and population status of elk, red deer, roe deer, wild boar, beaver, grouse and grouse, including the degree of predators’ influence on their productivity, and preparation of management plans for such populations”;

– a number of economic contracts for the development of biological justifications for the introduction of red deer into hunting farms of Belarus with hunting users in the period from 2017 to 2023, the main customers: RGOO “BOOR”, hunting users from the system of the Ministry of Forestry of the Republic of Belarus.

**Field of Application**

Hunting farms, Ministry of Forestry of the Republic of Belarus.

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State Scientific and Production Association "Scientific and Practical Center  
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## SCIENTIFIC SUPPORT FOR PRESERVATION OF BISON IN BELARUS



### Development Description

Biological justifications for the introduction of bison into the territory of individual land users, a bison settlement scheme in Belarus, a bison population management plan in the Republic of Belarus, an action plan for the conservation and rational use of a separate bison population, a set of biotechnical measures, recommendations for improving environmental conditions for bison subpopulations.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Corresponds to the best domestic and foreign analogues, cheaper than the best domestic and foreign analogues.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

– State Program “Environmental Protection and Sustainable Use of Natural Resources” for 2021–2025, subprogram 4 “Conservation and Sustainable Use of Biological and Landscape Diversity”, task 101 “Updating the plan for managing the Belarusian bison population, bison resettlement schemes, as well as developing (updating) action plans for free-living micropopulations”;

– Separate economic contracts for the resettlement and management of bison populations: 2021 “Biological substantiation of the bison (*Bison bonasus* L.) population in the State Unitary Enterprise “Berazinsky Biosphere Reserve”, “Updating of the action plan for the conservation and rational use of the Osipovichy bison micropopulation”, 2022. “Biological substantiation of bison (*Bison bonasus* L.) introduction in the State Forestry Institution “Klichevsky Leskhoz”, “Development of an action plan for the conservation and rational use of the Krasnoborskaya micro-population of bison”, 2023 “Biological substantiation of bison (*Bison bonasus* L.) introduction in the National Park “Braslav Lakes”.

**Field of Application**

Conservation of biological diversity, Ministry of Natural Resources and Environmental Protection of the Republic of Belarus.

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State Scientific and Production Association "Scientific and Practical Center  
of the National Academy of Sciences of Belarus on Bioresources"

## AXONOMIC COMPOSITION AND GENETIC DIVERSITY OF EAST ANTARCTIC BIOTA



### Development Description

For the first time in world practice, a taxonomic identification of 604 samples of East Antarctic biota organisms (Tala Hills (Enderby Land), Larse-



mann Hills (Prüds Bay), Schirmacher Oasis) was carried out and its genetic diversity was revealed: Chordata (Animalia) – 144; Echinodermata (Animalia) – 139; Ascomycota (Fungi) – 124; Bryophyta (Plantae) – 59; Arthropoda (Animalia) – 55; Annelida (Animalia) – 34; Chlorophyta (Plantae) – 15. The taxonomic identification of samples was carried out by DNA barcoding of 604 samples of organisms (fragments of tissues, bodies, thalli, microorganisms) out of 1000 collected by Belarusian biologists during scientific research in East Antarctica and transferred according to the agreement on transfer of genetic resources. All DNA barcode data of the identified species are entered into the international database BOLD to replenish the DNA barcode reference library.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no similar funds in Belarus. In terms of volume and representation of taxa of various groups of animals, it corresponds to the best collections in the world. The collections are unique, allow assessing the faunal diversity of the animal world.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Scientific and innovative activity of the National Academy of Sciences of Belarus” for 2021–2025, subprogram 2 “Development of the activity of the Belarusian Antarctic Station”, task “Study the dynamics of the state of biological diversity, develop a strategy and action plan for the conservation and sustainable use of biotic components of the Antarctic environment in the conditions of global and regional climate change and anthropogenic impact”.

Field of Application

Development of activity of the Belarusian Antarctic Station.

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State Scientific Institution  
“Forest Institute of the National Academy of Sciences of Belarus”

## TEST SYSTEM FOR EXPRESS-DIAGNOSTICS OF FOREST WOODY PLANTS MIXED INFECTIONS



### Development Description

The test system is designed for molecular genetic identification of species composition in associations of the main groups of phytopathogens based on the use of polymerase chain reaction (PCR) technology. The analysis algorithm includes: total DNA preparations obtaining (containing the genetic material of phytopathogens), amplification of pathogens diagnostic loci using classical PCR, electrophoretic analysis of amplicons, and interpretation of the results. This technology can be used to diagnose the main groups of phytopathogens of forest tree species in samples of plant material, pure cultures, soil and water etc. including the determination of latent infection in seed and planting material. Appropriate phytopathological analysis can be carried out by specialized laboratories of institutions and inspections on quarantine and plant protection, as well as scientific institutions.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no domestic analogues. Corresponds to the best foreign analogues.

Specifications:

– diagnostic period for bacterial phytopathogens (working days) – 1;

- diagnostic period for fungal phytopathogens (working days) – 1;
- diagnostic sensitivity of the test, not less (%) – 95.0;
- diagnostic specificity of the test, not less (%) – 99.0;
- diagnostic efficiency of the test, not less (%) – 95.0;
- predictive value of a positive test result, not less (%) – 99.0;
- predictive value of a negative test result, not less (%) – 90.0.

#### Intellectual Property Protection

Patent of the Republic of Belarus No. 21100.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Interstate Target Program of the Eurasian Economic Community “Innovative Biotechnologies”, 2011–2015; subprogram 1 “Innovative Biotechnologies in the Republic of Belarus”; task 4.15 “Develop and Implement a Test System for the Express Diagnosis of Mixed Infections of Forest Woody Plants Based on Metagenomic Analysis of Phytopathogen Species Associations”.

#### Field of Application

Forestry, gardening and park management.

#### Contact Information of Organization-Developer

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State Scientific Institution “V. F. Kuprevich Institute of Experimental Botany  
of the National Academy of Sciences of Belarus”

## MODIFIED ION-EXCHANGE IMMUNOMODULATING SUBSTRATE



Modified ion exchange substrate



Appearance of the virus-free potato seedlings

### Development Description

A highly productive nutrient substrate (medium) made of ion-exchange and inert materials saturated in optimal doses and ratios with macro and microelements of plant nutrition, including immunomodulating compounds capable of increasing adaptive potential, maintaining active growth and productivity of plants in adverse environmental conditions. They can be used for growing plants in indoor farming or closed life support systems, as fertilizer additives in substrates and soil mixtures in closed growing systems and agriculture.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Growing plants for a long time without additional fertilization, excluding leaching of fertilizers during watering. Biological purity of the substrate.

Formation of a powerful root system, acceleration of plant growth and development. It is able to increase the adaptive potential, maintain active growth and productivity of plants in adverse environmental conditions, protect against plant reinfection during the adaptation period of ex vitro microclonally propagated plants, increase the yield of environmentally friendly products. Due to the inclusion of immunomodulating compounds, it surpasses Russian analogues.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-Tech Technologies and Engineering”, 2016–2020; subprogram 1 “Innovative biotechnologies – 2020”; task 34 “Ecotechnology for increasing the immunostability of primary potato material in protected soil using methods of plant nanopharmacology”.

**Field of Application**

Closed growing systems and agriculture.

**Contact Information of Organization-Developer**

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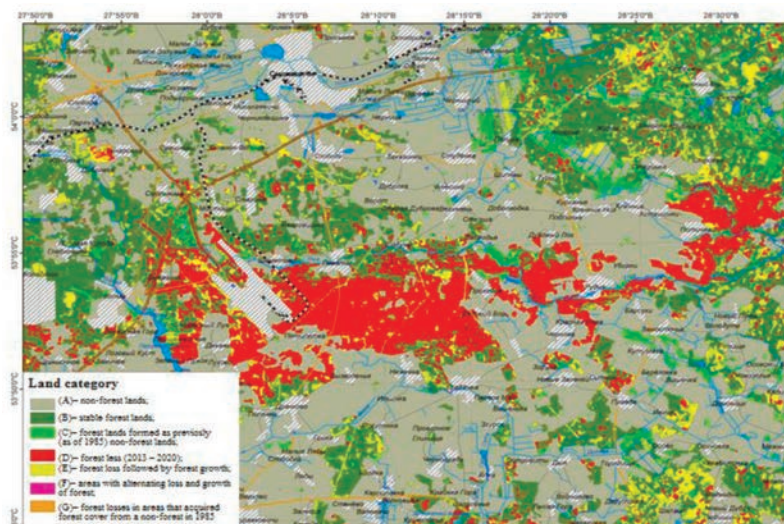
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State Scientific Institution “V. F. Kuprevich Institute of Experimental Botany  
of the National Academy of Sciences of Belarus”

## NATURAL ECOSYSTEMS REMOTE MONITORING TECHNOLOGIES



Forest Vegetation Cover Dynamics Digital Map (fragment)

### Development Description

Principles and methods of large-scale geobotanical and environmental mapping of vegetation cover using GIS technologies and Earth remote sensing data have been developed. The “technological chain” has been developed from obtaining a satellite image to creating thematic maps with various content (deforestation, natural disasters, epidemics, food security, climate change, and environmental protection). Digital large-scale Maps of Vegetation have been compiled for all the largest specially protected natural areas of the Republic of Belarus (national parks “Belovezhskaya Pushcha”, “Narochansky”, “Pripyatsky”, Berezinsky Biosphere Reserve), underway to create a digital map of Vegetation of Belarus, a map of the Mires of Belarus been created.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The development is an example of the best national practice and is not inferior in innovation to foreign analogues. The following factors determine the economic feasibility of developing remote sensing technologies for studying the vegetation cover of Belarus:

- any point of the country can be subjected to research, including hard-to-reach and dangerous regions (for example, the 30-kilometer zone around the Chernobyl nuclear power plant; the impassable mires of Polesie);

- the technology use will reduce the cost of conducting an inventory of vegetation objects by 2.5–3 times (13–15 people × day/1000 ha using ground-based methods versus 5 people × day/1000 ha using remote sensing); improve the quality and efficiency of recording current changes in vegetation cover by 1.5–2 times;
- scale of research: the area covered by one satellite image can reach tens of thousands of square kilometers;
- the cost per unit volume of aerospace survey materials in relation to ground surveys is 1:3;
- the cost of services provided by the national remote monitoring system is significantly lower than foreign analogues. Remote monitoring services for vegetation cover can be provided for the territory of the Russian Federation, its regions, for local areas of interest to individual companies and commercial organizations, as well as for the territories of various countries (CIS, Europe, Asia).

#### Intellectual Property Protection

The methodology for conducting ecosystems comprehensive monitoring in specially protected natural areas as part of the National Environmental Monitoring System of the Republic of Belarus (approved by the Resolution of the Presidium Bureau of the National Academy of Sciences of Belarus on December 4, 2020 No. 547). Instructions on the procedure for conducting ecosystems comprehensive monitoring in specially protected natural areas (approved by the Resolution of the Presidium Bureau of the National Academy of Sciences of Belarus on December 4, 2020 No. 547).

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-Tech Technologies and Engineering”, 2016–2020; task 101 “Create a comprehensive monitoring system of the protected areas vegetation cover using Earth remote sensing data” (state registration number 20164021).

#### Field of Application

Environmental audit, environmental monitoring, environmental control, compiling, editing and designing maps, protected areas and water areas of regions and countries.

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State Scientific Institution “Central Botanical Garden  
of the National Academy of Sciences of Belarus”

## VARIETY OF WHITE GREEK LUPINE “ELLIN”



Variety of white Greek lupine “Ellin” (*Lupinus albus* L. subsp. *graecus* (Boiss. et Sprun.) Franko et Silva)

### Development Description

The variety of white lupine “Ellin” is the first variety of the white Greek lupine in Belarus (*Lupinus albus* L. subsp. *graecus* (Boiss. et Sprun.) Franko et Silva). The variety has dark green xeromorphic leaves, blue flowers and white seeds with brown marbling. The “Ellin” variety is tolerant to fusarium and anthracnose, resistant to cracking of beans, drought and frost down to  $-7^{\circ}\text{C}$ . The variety of the grain direction of use:

- it has an average initial growth rate and reduced corymbose-type sympodial branching, which ensures smooth ripening of beans;
- weight of 1000 seeds is 291 g;
- protein content in seeds is 34 %;
- oil is 10 %;
- alkaloids are 0.08 %.

A medium-ripened variety, the growing season from sowing to full ripening (BBCH 91) is 113 days. Since 2022, the “Ellin” variety has been included in the State Register of Plant Varieties.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no analogues in the world.

**Intellectual Property Protection**

White Greek lupine (*Lupinus albus* L. subsp. *graecus* (Boiss. et Sgip.) Franco et Silva) “Ellin”: patent BY 669 / N. S. Kuptsov, B. Yu. Anoshenko, V. V. Titok, P. A. Pashkevich. – Publ. 15.03.2023.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Industry scientific and technical program “Introduction, landscaping, environmental safety” for 2016–2020, subprogram 1 “Introduction and landscaping”, task 2.1.7 “Create effective varieties of medicinal, aromatic and bioenergy plants”.

**Field of Application**

Agriculture.

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State Scientific and Production Association  
“Chemical Synthesis and Biotechnology”

## MICROBIAL PREPARATION “BIOPRUD”



### Development Description

The microbial preparation “Bioprud” is intended for remediation and enrichment of fish ponds with nutrients.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The basis of the microbial preparation “Bioprud” are strains of spore-forming bacteria of genus *Bacillus* with high antimicrobial, hydrolytic, phosphate-mobilizing and nitrogen-fixing activities, aimed at releasing the nutrients from the pond bed and converting them into the form accessible for further assimilation, as well as at regulating the population and composition of pathogenic microbiota. The use of the microbial preparation contributes to increase the natural fish productivity by 40–60 %, to reduce feed cost by 29,7%, and to save the supply of mineral nitrogen-phosphorus fertilizers by 60% as compared to standard doses.

### Intellectual Property Protection

The technology of producing microbial preparation “Bioprud” is guarded as a trade secret (Order No. 41-OD dated 12.08.2023).

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-tech processes and equipment” for 2021–2025, subprogram “Innovative biotechnologies”, task 64 “Develop a technology for producing a microbial preparation for remediation and enrichment of fish farming ponds with nutrients”.

**Field of Application**

Commercial fish farming.

**Contact Information of Organization-Developer**

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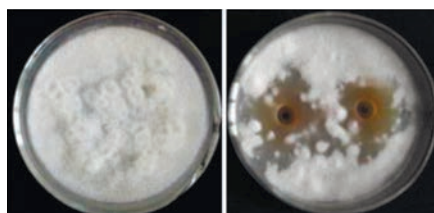
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State Scientific and Production Association  
"Chemical Synthesis and Biotechnology"

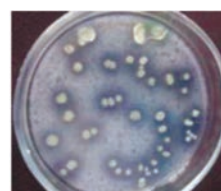
## BIOPRODUCTIN MICROBIAL PREPARATION



Growth inhibition zones of phytopathogenic fungus *Fusarium oxysporum* caused by the impact of Bioproductin preparation



Nitrogen-fixing activity of Bioproductin preparation



Mobilization of insoluble calcium phosphate  $\text{Ca}_3(\text{PO}_4)_2$

### Development Description

Bioproductin microbial preparation was designed to increase the biological activity of the soil, improve the phytosanitary condition of crops and an intensive apple orchard, increase the yield of cereals and apples. The preparation is based on spores and metabolites of bacteria *Bacillus amyloliquefaciens*, *Bacillus mojavensis* and *Priestia megaterium* (the titer is at least  $1 \times 10^9$  CFU/ml).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The constituent bacteria action is aimed at alleviating infectious background of grain seedlings and apple of intensive garden, accelerating mineralization of post-harvest plant residues, recovery of soil microbial cenoses, ameliorating of phosphorus and nitrogen nutrition of cultivars, reducing in number of fungicide treatments, and lowering doses of applied mineral fertilizers. The biological efficiency of Bioproductin against snow mould constitutes 10–15 %, against root rots – 26–56 %, reaches 40–50 % in control of powdery mildew. Grain extra yields upon Bioproductin application attain 4.2–6.1 c/ha. The introduction of the microbial preparation “Bioproductin” into the trunk strip of apple trees by spraying in the phase of the beginning of budding of the crop and after harvesting provides a thickening of tree strains by 0.3 cm, the content of soluble sugars of apples by 0.8%, an increase in yield by 19.4 c/ha, and an average fruit weight of 3.3 g. Major advantages of the product: A broad spectrum of action due to several bacterial strains combined in the same formula and showing specificity toward diverse phytopathogenic species infecting cereal crops and apple of intensive garden; Output of eco-friendly farm products.

#### Intellectual Property Protection

The protection of intellectual property is maintained as a valuable trade secret.

#### Name of the programme, subprogramme, project, business contracts under which the development was obtained

State Program “Science-based technologies and machinery”, 2016–2020; subprogram 1 “Innovative biotechnologies-2020”; task 70 “Develop and scale up technology of producing complex microbial preparation Bioproductin to promote biological activity of soil, to upgrade phytosanitary status of seedlings and to raise productivity of grain crops”; State scientific and technical program “Promising chemical and biological technologies”, 2021–2025, subprogram “Industrial biotechnologies – 2025”, task 5-02 “To develop and implement promising technological methods to increase the yield and quality of apple fruits in an intensive dwarf orchard”.

#### Field of Application

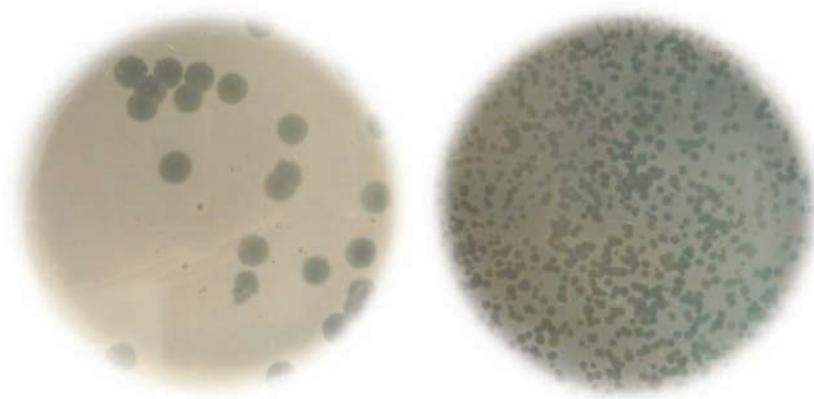
Plant cultivation.

#### Contact Information of Organization-Developer

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State Scientific and Production Association  
"Chemical Synthesis and Biotechnology"

## MULTIPHAGE-C BIOPREPARATION



Lysis zones of phytopathogenic bacteria formed under the impact of Multiphage-C biopreparation

### Development Description

Multiphage-C is intended to control bacterial diseases of tomato in greenhouses. The biopreparation is composed of phages antagonistic against pathogens responsible for core stem necrosis and bacterial black spot of tomato (the titer is at least  $1 \times 10^8$  PFU/ml).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The application of the phage preparation reduces incidence of bacterial tomato infections by 59–69 % and augments vegetable harvests by 28–33 %.

Major benefits of the product:

- it has no domestic analogues;
- the application of bacteriophages as product ingredients enables to focus specific influence on phytopathogenic bacteria and by-pass adverse effects on other biological species;
- a wide application range by pooling in the same product of several phages specific toward different phytopathogenic bacteria;
- lack of toxic and allergenic action.

**Intellectual Property Protection**

Know-how of Multiphage-C biopreparation producing technology is protected as a valuable trade secret.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based technologies and machinery”, 2016–2020; subprogram 1 “Innovative biotechnologies-2020”; task 80<sup>3</sup> “Develop and scale up technology of producing biopreparation to control bacterial diseases of vegetable crops”.

**Field of Application**

Plant cultivation.

**Contact Information of Organization-Developer**

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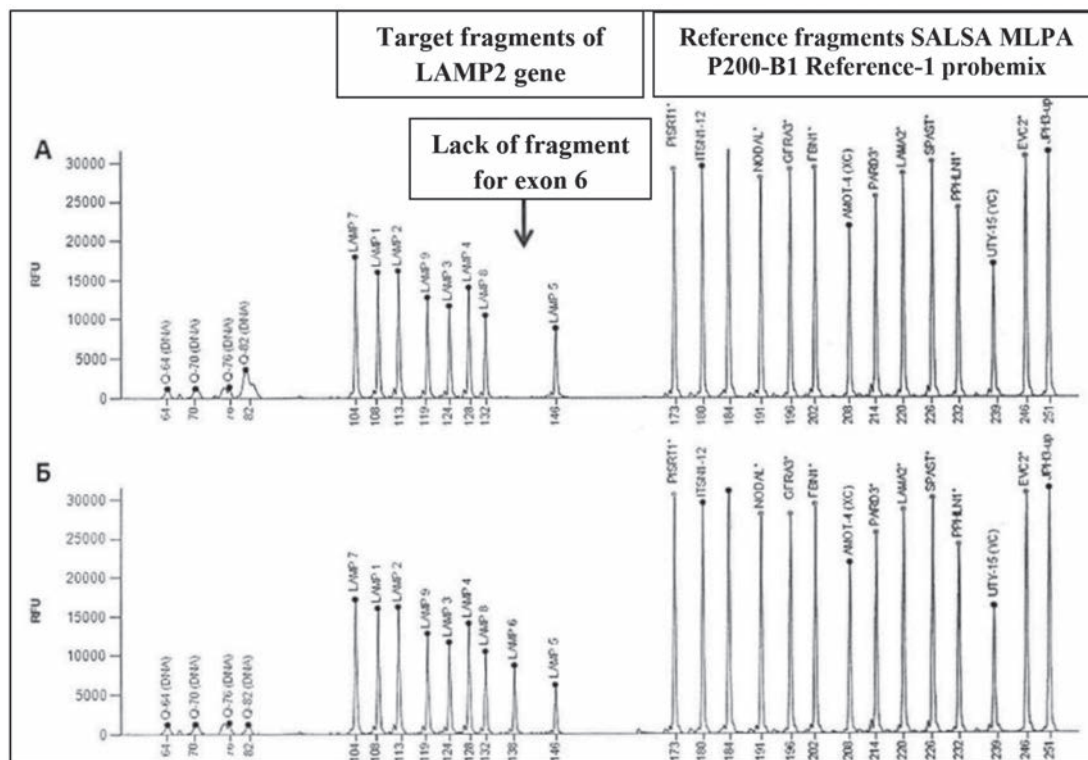
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State Scientific Institution Institute of Genetics and Cytology  
of the National Academy of Sciences of Belarus"

## SET OF SPECIFIC HYBRIDIZATION PROBES FOR DETERMINING CHANGES IN THE LYSOSOMAL-ASSOCIATED PROTEIN-2 (LAMP2) GENE IN HUMANS BY THE MLPA METHOD FOR DANON DISEASE DIAGNOSIS



### Development Description

Hybridization probes highly sensitive to nine exons of LAMP2 gene for multiple ligations with subsequent amplification (MLPA) have been developed. They allow detecting deletions and duplications in LAMP2 gene, as well as changes in its copy number. They are intended for the diagnosis of Danon disease when it is suspected based on clinical manifestations, as well as for studying changes in the structure of LAMP2 gene in humans for research purposes. They are designed to all coding exons of LAMP2 gene and meet the requirements for MLPA probes.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The main advantage of the method is ability to detect different types of gene variation including deletions, duplications and SNPs. The method does not have any national analogues.

**Intellectual Property Protection**

Hybridization probes highly sensitive to nine exons of LAMP2 gene. Patent of the Russian Federation No. 2781084.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-technical program of the Union State “Development of innovative genogeographic and genomic technologies for identifying personality and individual characteristics of a person based on the study of the gene pools of the Union State Regions” (“DNA identification” 2017–2021); project “Identification of DNA markers for the risk of non-coronary heart diseases.”

**Field of Application**

Molecular biology and medical genetics.

**Contact Information of Organization-Developer**

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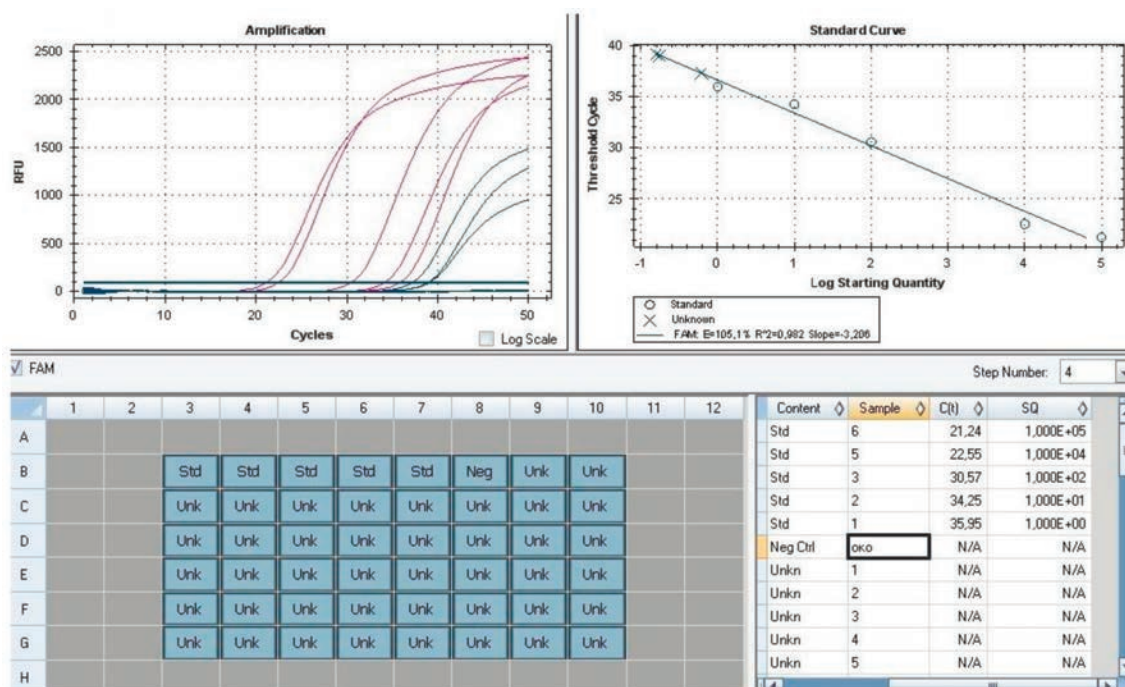
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State Scientific Institution Institute of Genetics and Cytology  
of the National Academy of Sciences of Belarus"

## METHOD FOR THE CATTLE LEUKEMIA DIAGNOSIS



### Development Description

The method for diagnosing of bovine leukemia allowing the direct detection of bovine leukemia provirus DNA with high sensitivity and specificity in a one-step amplification procedure has been developed. The method for bovine leukemia diagnosing using the real-time PCR (TaqMan) can be used as a supplement to and control over the results of traditional methods for diagnosing bovine leukemia at the livestock farms of the Republic of Belarus.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The development has no analogues in Belarus. The proposed method allows to increase the reliability of detection of BLV in the early stages of infected animals in comparison with the traditionally used enzyme immunoassay method and to increase the efficiency of leukemia diagnostics. The specificity of the diagnostic test system is indicated by the ability to detect the presence of provirus bovine leukemia (BLV) by one specific

melting peak in the test sample, located above the threshold line during RT-PCR. The sensitivity of the diagnostic test system allows detecting at least 10 copies of the desired proviruses in the test sample.

**Intellectual Property Protection**

Patent BY No. 21227.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Innovative biotechnology” for 2010–2012 and til 2015; subprogram “Agricultural biotechnology (livestock)”; project “Develop highly sensitive methods for the gene diagnostics of retroviral infections of farm animals”.

**Field of Application**

Veterinary virology and biotechnology.

**Contact Information of Organization-Developer**

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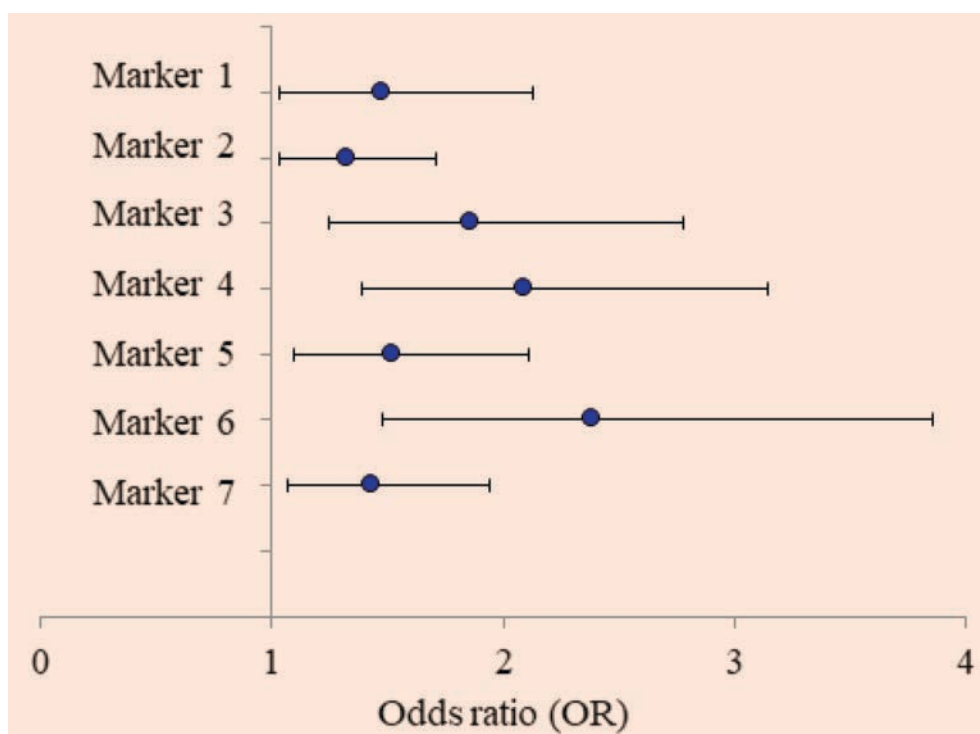
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State Scientific Institution Institute of Genetics and Cytology  
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## METHOD FOR DETECTING A GENETIC PRESPOSITION TO JOINT INFLAMMATION IN CHILDREN



Association of DNA markers with joint inflammation in children

### Development Description

The method for identifying genetic predisposition to joints inflammation in children increasing the reliability of detecting a genetic predisposition to the development of an inflammatory process in joints has been developed. The development is based on the identification of marker alleles associated with a genetic predisposition to the development of inflammatory processes of various etiology in the joints of pediatric patients. Examination of children is carried out by genotyping of DNA samples.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no analogues. The method is based on the innovative and cost-effective approach.

**Intellectual Property Protection**

The method for identifying a genetic predisposition to joints inflammation in children. The development (as know-how) is protected as a trade secret.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Scientific-technical program of the Union State “Development of innovative genogeographic and genomic technologies for identifying personality and individual characteristics of a person based on the study of the gene pools of the Union State Regions” (“DNA identification” 2017–2021), project “Molecular genetic assessment of autoimmune diseases’ risk.”

**Field of Application**

Molecular biology and medical genetics

**Contact Information of Organization-Developer**

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State Scientific Institution "Institute of Genetics and Cytology  
of the National Academy of Sciences of Belarus"

## DNA IDENTIFICATION AND IDENTIFICATION OF VARIETIES OF BERRY CROPS



### Development Description

For the successful implementation of selection programs, the identification of genotypes of varieties, hybrids, and initial forms used in the selection process is of great importance.

The laboratory of molecular genetics has developed a DNA identification method based on the use of 8 highly informative SSR markers, which allows DNA identification and certification of garden strawberry varieties in accordance with the criteria of the DUS test. A single set of 8 DNA markers has been developed, which allows DNA identification and certification, as well as verification of the relationship of varieties of black currants, red currants, common gooseberries, wild and decorative representatives of the genus *Ribes*, as well as interspecies hybrids.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Technical advantages:

- High accuracy in determining varietal identity.
- Requires a minimum amount of plant tissue taken from any part of the plant.

- Determination time: 2–3 days.
- The method is applicable at any time of the year.

DNA methods for identifying varieties of berry crops have no domestic analogues and correspond to the best world analogues.

#### Intellectual Property Protection:

– Patent of the Republic of Belarus No. 23966 “A set of molecular markers of SSR-type and a method for DNA identification of plant varieties of the *Fragaria* genus” by O. Yu. Urbanovich, O. A. Mezhnina. Patent holder: State Scientific Institution “Institute of Genetics and Cytology of the National Academy of Sciences of Belarus”, publ. 30.04.2023;

– Patent of the Republic of Belarus No. 23967 “A set of SSR-type molecular markers and a method for DNA identification of varieties of black currants, red currants, and common gooseberries” by O. Yu. Urbanovich, O. A. Mezhnina. Patent holder: State Scientific Institution “Institute of Genetics and Cytology of the National Academy of Sciences of Belarus”, publ. 30.04.2023.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Agropromcomplex” for 2013–2015, subprogram “Agropromcomplex – sustainable development”, task 2.72 “Create varieties of fruit and berry crops that meet the requirements of intensive fruit growing, based on genetic collections of various categories and types”.

#### Field of Application

Agriculture.

#### Contact Information of Organization-Developer

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State Scientific Institution "Institute of Genetics and Cytology  
of the National Academy of Sciences of Belarus"

## DNA IDENTIFICATION AND IDENTIFICATION OF VARIETIES OF FRUIT CROPS



### Development Description

Universal systems of DNA identification and certification of seed and stone fruit crops grown in the Republic of Belarus, including varieties of apple, pear, plum, cherry, apricot and cherry, have been developed. The DNA analysis method using the developed sets of SSR markers allows to obtain unique molecular genetic profiles of varieties of fruit crops grown in the Republic of Belarus, and to carry out DNA identification of genotypes in accordance with the criteria of distinguishability, uniformity and stability of the DUS test. Based on the use of DNA markers, methods have been developed for identifying genes for resistance to powdery mildew and scab in the genome of apple varieties and hybrids grown in Belarus, which are used in the selection process to create starting breeding material and hybrids with complex resistance to diseases and pests.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Technical advantages:

- High accuracy in determining varietal identity.
- Requires a minimum amount of plant tissue taken from any part of the plant.
- Determination time: 2–3 days.
- The method is applicable at any time of the year.

DNA methods for identifying varieties of fruit crops have no domestic analogues and correspond to the best world analogues.

**Intellectual Property Protection**

– Patent of the Republic of Belarus No. 21664 “A set of molecular markers of SSR type and a method for DNA identification of varieties of cherries, cherries, domestic plums, diploid plums, apricots, and their hybrids” by O. Yu. Urbanovich, P. V. Kuzmitskaya, Z. A. Kozlovskaya. Patent holder: State Scientific Institution “Institute of Genetics and Cytology of the National Academy of Sciences of Belarus”, publ. 28.02.2018;

– Patent of the Republic of Belarus No. 23427 “A set of molecular markers for microsatellite repeats in the apple tree genome and a method for DNA identification of apple tree varieties” by O. Yu. Urbanovich, P. V. Kuzmitskaya, O. A. Mezhnina, E. P. Kvetko. Patent holder: State Scientific Institution “Institute of Genetics and Cytology National Academy of Sciences of Belarus”, publ. 30.06.2021.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Research work “Study of the contribution of tetranucleotide repeats to the polymorphism of varieties and species of representatives of the genus *Malus*”, carried out under the contract with BRFFI No. B18M-040 dated 30.05.2018. Implementation period: 2018–2020.

**Field of Application**

Agriculture.

**Contact Information of Organization-Developer**

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**State Scientific Institution “Institute of Microbiology  
of the National Academy of Sciences of Belarus”**

## **MICROBIAL PREPARATION BIOKIT**



### **Development Description**

Concentrated ecologically safe microbial preparation BioKiT with prolonged action based on consortium of *Rhodococcus* bacteria is designed to decontaminate wastewaters and absorption solutions polluted with xylene and toluene.

The efficiency of xylene sorption from aqueous solutions reaches 75–99 %, toluene sorption – 80–100 % depending on concentration of toxicants. The recovery of multicomponent effluents with chemical oxygen demand (COD) 3500–7500 mg O<sub>2</sub>/L containing xylene, toluene, and additional substances constitutes 80–95 %. The supply of BIOKIT into wastewater to promote the operation of activated sludge enables to attain stable performance of biodecontamination networks exposed to peak input of elevated xylene and toluene levels. BIOKIT may be applied to regenerate water solutions polluted with xylene and toluene in chemical, petrochemical paints and varnish manufacturing plants, industries with dye-coating units.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

BioKiT may be applied as activated sludge mixture in biological detoxification systems.



The efficiency of xylene sorption from aqueous solutions reaches 75–99 %, toluene sorption – 80–100 % depending on concentration of toxicants. The recovery of multicomponent effluents with chemical oxygen demand (COD) 3500–7500 mg O<sub>2</sub>/L containing xylene, toluene, and additional substances constitutes 80–95 %. The supply of BIOKIT into wastewater to promote the operation of activated sludge enables to attain stable performance of biodecontamination networks exposed to peak input of elevated xylene and toluene levels. BIOKIT may be applied to regenerate water solutions polluted with xylene and toluene in chemical, petrochemical plants and varnish manufacturing plants, industries with dye-coating units. The development has no analogues in the world.

#### Intellectual Property Protection

Microbial preparation BIOKIT and the related know-how of the technology of producing microbial preparation BIOKIT are trade secrets.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-oriented technologies and machinery”, 2016–2020; subprogram 1 “Innovative biotechnologies-2020”; task 821 “Develop technology for producing microbial preparation to remove xylene and toluene contaminants from aqueous solutions”.

#### Field of Application

Environmental protection (disposal of effluents).

#### Contact Information of Organization-Developer

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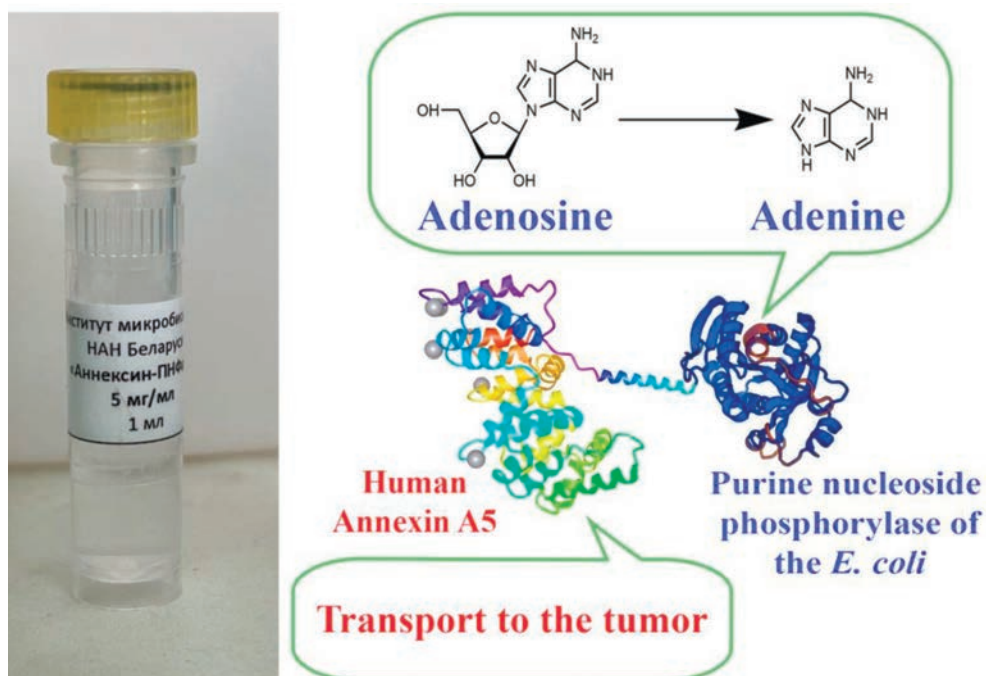
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State Scientific Institution "Institute of Microbiology  
of the National Academy of Sciences of Belarus"

## ANNEXIN-PNPase CHIMERIC PROTEIN PRODUCED BY RECOMBINANT STRAIN OF BACTERIA *ESCHERICHIA COLI*



### Development Description

Annexin-A5 protein shows enhanced affinity to phosphatidylserine (phospholipid presented on the surface of tumor cells), making it extremely attractive for use as the selective carrier into malignant tumor of target compounds (drugs, enzymes, etc).

Most malignant tumors are distinguished by increased generation of adenosine inhibiting cancerostatic immune response in humans. Purine nucleoside phosphorylase (PNPase) catalyzes reaction of transformation adenosine to adenine, thereby liberating tumor microenvironment from adenosine blockade and activating antitumor immune response.

The conjunction of annexin-A5 and PNPase into consolidated chimeric protein structure will ultimately engage it for stimulation of host immunity and for pro-drug therapy of oncopatients (upon completion of preclinical and clinical trials).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Highly efficient recombinant strain was developed to produce human annexin-A5 connected to purine nucleoside phosphorylase of *E. coli*. The synthesized chimeric protein is characterized by enhanced PNPase activity (at least 10,000 units per 1 ml of culture broth). The precisely delivered protein is likely to bind to its molecular target – phosphatidylserine in cancer cells not affecting healthy host tissues. In USA, the similar drug is undergoing clinical trials.

**Intellectual Property Protection**

Patent of the Republic of Belarus No. 23404 (published in the official patent bulletin on March 29, 2021).

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Biotechnologies”, 2016–2020; subprogram “Microbial biotechnologies”; task 3.32 “Elaboration of the method to produce recombinant human annexin connected to bacterial purine nucleoside phosphorylase”.

**Field of Application**

Medicine.

**Contact Information of Organization-Developer**

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State Scientific Institution “Institute of Microbiology  
of the National Academy of Sciences of Belarus”

## BILAMETRITIS PROBIOTIC PREPARATION



Manufactured as foam-generating tablets or powder

### Development Description

Bilametrit probiotic bacterial preparation based on freeze-dried viable lactic acid bacterial cells of genera *Lactobacillus* and *Lactococcus* (the titer at least  $1 \times 10^{10}$  CFU/g) is intended for prevention and complex therapy of endometrites in cows.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Bacterial components of biopreparation suppress growth of pathogenic microorganisms of *Staphylococcus*, *Streptococcus*, *Pseudomonas*, *Escherichia coli* genera – pathogen factors of endometrites; owing to the pronounced adhesive capacity they normalize microbiom of reproductive organs of cows affected by antibiotic therapy; they promote regeneration of endometrium, produce organic acids, antimicrobial peptides, aminoacids, enzymes regulating metabolism of carbohydrates and proteins. Main advantages: the veterinary probiotic supply promotes prophylaxis and reduces incidence of acute postpartum endometrites cases in cows by 50–92.5 %, curtails duration of disease by 1–2 days. The biopreparation may be applied as foam-generating tablets or powder forms.

The use of Bilametrit in combination with uterine massage and uterotonic drugs will reduce the use of antibiotics, improve the quality and environmental safety of products, and ensure high sanitary quality of milk.

Bilametrit is not inferior to analogues in effectiveness of prevention of postpartum endometritis in cows, has an advantage in technical and economic indicators (dry form of the drug, high concentration of bacterial cells, shelf life – at least 12 months).

#### Intellectual Property Protection

Technology specifying know-how of producing Bilametritis probiotic preparation (process regulations) is protected as a trade secret.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Industrial bio-and nanotechnologies-2020”, 2016–2020; Task 4-21 “Develop and scale up technology of manufacturing probiotic preparation for prevention and comprehensive treatment of endometrites in cattle”; State Research Program “Promising chemical and biological technologies”, 2021–2025; subprogram “Industrial biotechnologies-2025”.

#### Field of Application

Agriculture (stock breeding), veterinary practice.

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State Scientific Institution "Institute of Microbiology  
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## PHLEBIOPIN BIOPREPARATION



### Development Description

Phlebiopin is an eco-safe agent for the biological control of annosus root rot pathogen and recovery of forest biocenoses (the min titer is  $3.5 \times 10^6$  CFU/ml). The biopreparation is based on oidiospores and mycelium fragments of basidial fungus *Phlebiopsis gigantea* responsible for degradation of decaying wood. It shows antagonistic properties against root rot pathogen *Heterobasidium annosum*.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Phlebiopin application during sanitation felling and rehabilitation events limits infection area and decreases spreading rate of root rot by restricting access of pathogen to the consumable substrate – wood of stumps and roots, diminishes stock of pathological tree loss from 20.9 to 6.2 %.

Major advantages of the product:

- lack of local competitors;
- ensuring high efficiency of preventing annosus root rot outbreaks on the treated forest lands;
- decreasing of phytosanitary risks imposed by introduced alien bio-agents by substituting antagonistic strains of Belarusian selection;
- possessing increased competitive export potential.

#### Intellectual Property Protection

The know-how of Phlebiopin biopreparation producing technology is protected as a valuable trade secret.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-based technologies and machinery”, 2016–2020; subprogram 1 “Innovative biotechnologies-2020”; task 62 “Develop and scale up technology of producing preparation based on basidiomycete *Phlebiopsis gigantea* to control annosus root rots of conifers”.

#### Field of Application

Forestry.

#### Contact Information of Organization-Developer

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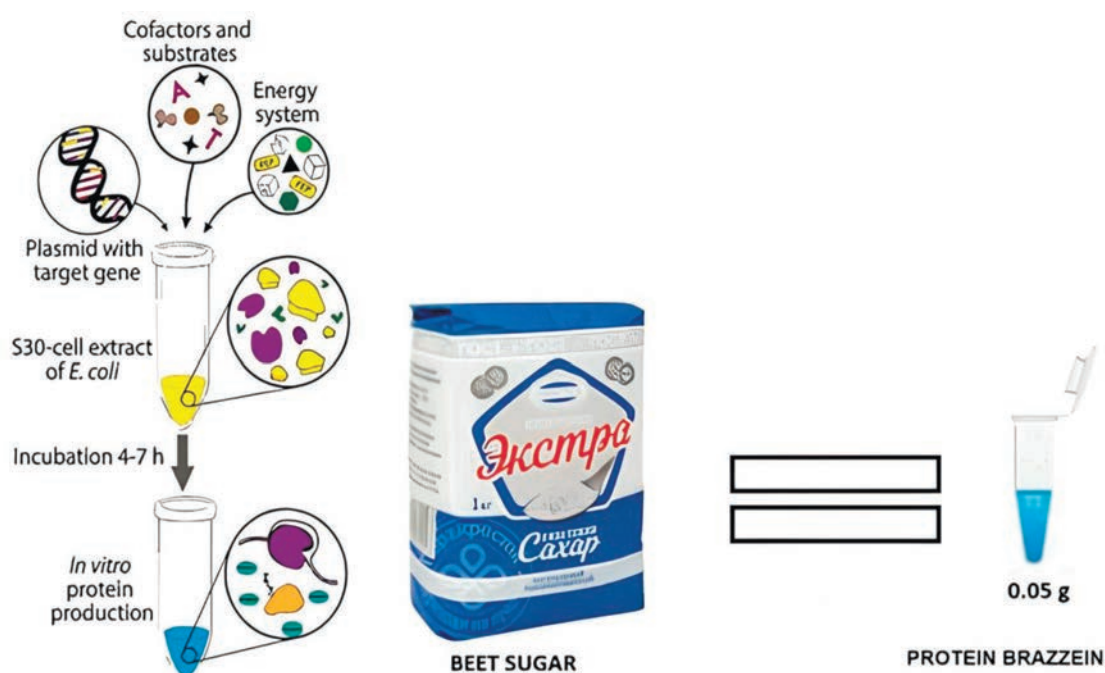
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State Scientific Institution “Institute of Microbiology  
of the National Academy of Sciences of Belarus”

## CELL-FREE SYNTHESIS OF PROTEIN WITH INTENSIVE SWEET TASTE – BRAZZEIN



### Development Description

Method for synthesis in bacterial cell-free translation system of vegetable protein with intensive sweet taste brazzein has been developed. The produced protein is absolutely safe natural sweetener showing almost zero calorific value. It is several thousand times sweeter than sucrose and has an aftertaste similar to saccharose. The technology opens new frontiers for applying innovative sugar substitutes of novel generation in medicine and food processing. The derived protein can be used in various branches of pharmacology and in spheres related to dietetic nutrition.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Local analogues are not available. Foreign counterparts are based on the well-known whole-cell expression systems resulting either in low yields of the target product, synthesis of insoluble brazzein forms or the reduced sweetness of brazzein molecule.

### Intellectual Property Protection

Patent of the Republic of Belarus was granted for the invention No. 23287 “A method of brazzein production” (published in the official patent bulletin on December 30, 2020).

### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Self-initiated studies.

### Field of Application

Food industry, medicine.

### Contact Information of Organization-Developer

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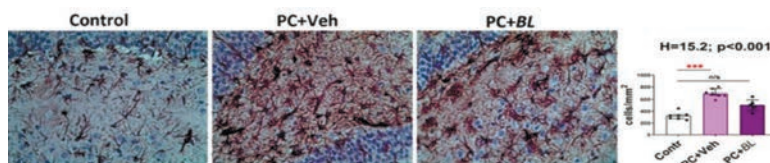
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# DEPARTMENT OF MEDICAL SCIENCES

State Scientific Institution "Institute of Physiology  
of the National Academy of Sciences of Belarus"

## NEUROPROTECTIVE PROPERTIES OF *BIFIDOBACTERIUM LONGUM* IN THE TEMPORAL LOBE EPILEPSY MODEL



1. Development of temporal lobe epilepsy model leads to increase in astroglia density (brown staining, model+vehicle) (PC+Veh, negative control) comparing to healthy control);
2. Consumption of *Bifidobacterium longum* decrease neuroinflammation in the temporal lobe during model development according according to astroglia density (PC+BL comparing to PC+Veh).

### Development Description

The neuroprotective properties of probiotic bacteria *B. longum* was shown in the lithium-pilocarpine model of temporal lobe epilepsy. It was also found that one of the mechanisms of such a positive effect is the decrease of astrogliosis in the temporal lobe. In addition, in the same model the neuroprotective effects of agonists of all three subtypes of PPARs were revealed.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Synergism of PPARs agonists and probiotics was shown at the first time.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

BRFFR-RFFR grant No. M20P-328 "Central and peripheral peroxisome proliferator-activated receptors as factors of epileptogenesis regulation" (2020–2022).

### Field of Application

Pathophysiology, pharmacy, neurology.

### Contact Information of Organization-Developer

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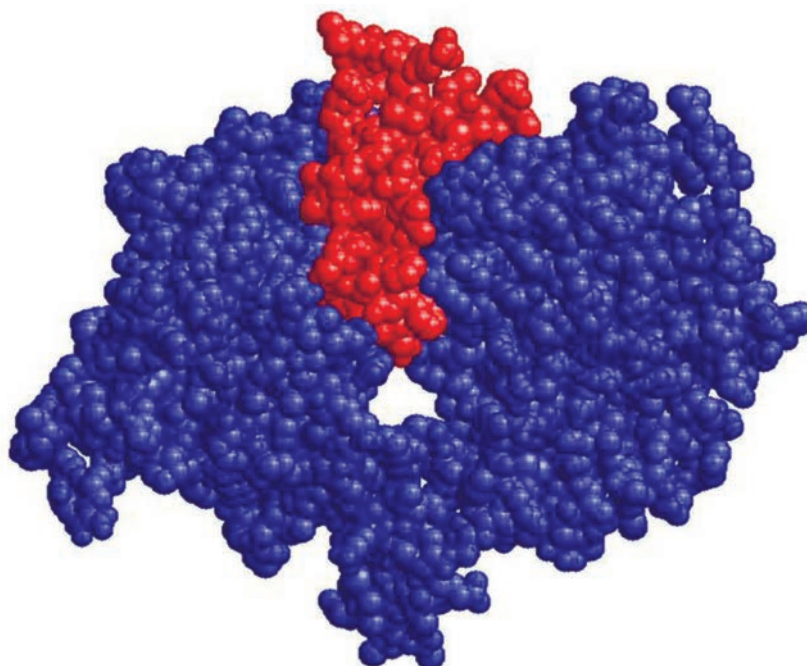
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State Scientific Institution  
“Institute of Physiology of the National Academy of Sciences of Belarus”

## HUMAN EPIDERMAL GROWTH FACTOR WITH AMINO ACID SUBSTITUTION D46G



### Development Description

The human epidermal growth factor with amino acid substitution D46G was constructed. It has been proven that in the dimer structure, peptide molecules are connected due to the antiparallel intermolecular beta structure formed by their C-terminal fragments. This peptide was found to cause a delay in tumor cell proliferation *in vitro* and *in vivo*. Despite the presence of an amino acid substitution and increased stability of the dimeric form, the peptide with the mutation is able to bind to domain III of the corresponding human receptor, but does not cause its activation, thus exhibiting antagonistic properties.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The amino acid substitution D46G did not occur during evolution. For the first time, the antitumor effect of human epidermal growth factor carrying this replacement has been demonstrated.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Agreement with BRFFR № B20M-025 “Development of an epidermal growth factor receptor antagonist based on a modified epidermal growth factor”, 04.05.2020 – 31.03.2022.

Field of Application

Molecular oncology, mathematical biology and biological processes theoretical modeling, bioinformatics.

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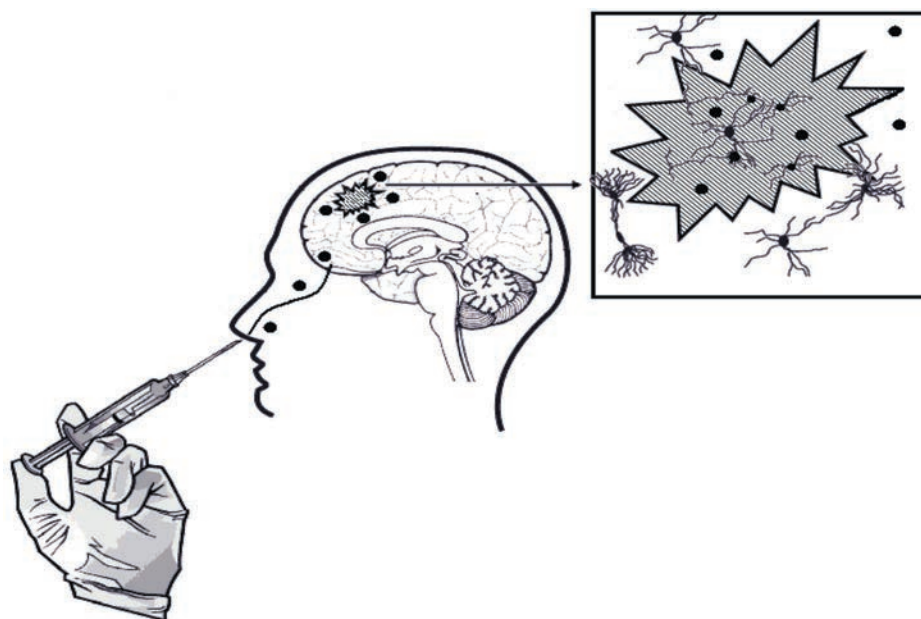
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State Scientific Institution  
"Institute of Physiology of the National Academy of Sciences of Belarus"

## TECHNOLOGY OF PERINEURAL STEM CELL MIGRATION



### Development Description

Technology of perineural migration of stem cells into areas of brain or spinal cord injury was developed at the Center of Brain to increase the effectiveness of cell therapy in traumatic injuries of the brain and spinal cord. Taking into account the somatotopic principle of innervation of organs and tissues, mesenchymal stem cells are implanted into the area of tissue innervation by a specific nerve. Further, by perineural transport, mesenchymal stem cells migrate to damaged areas of the brain and spinal cord.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

In contrast to the traditional clinical therapy of brain injuries, the technology of perineural stem cell migration has been introduced. The doctor implants stem cells in the endings of a specific nerve. Stem cells migrate along this nerve to damaged areas of the brain and spinal cord. There are no analogues in Belarus.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “New methods of medical care” for 2016–2020, subprogram “Transplantation of cells, tissues and organs”, project 01.16/2 with the Republican Scientific and Practical Center of Neurology and Neurosurgery “Develop a method for the treatment of cerebral strokes using stem cells in an experiment” as part of task 01.16 “Develop and implement a method for the treatment of cerebral strokes using stem cells”.

**Field of Application**

Experimental and clinical neurology and neurosurgery, nanobiotechnology.

**Contact Information of Organization-Developer**

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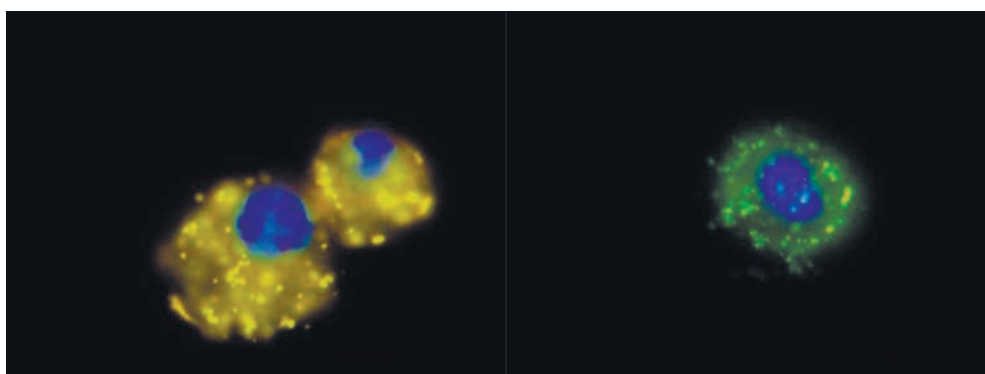
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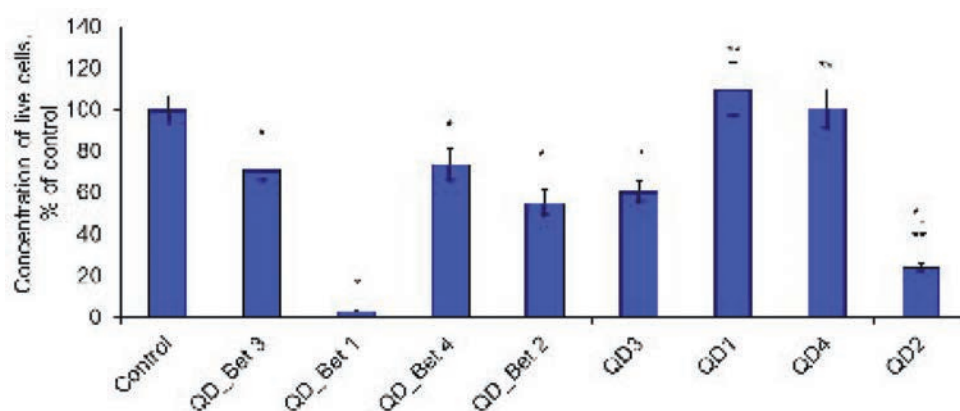
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State Scientific Institution  
“Institute of Physiology of the National Academy of Sciences of Belarus”

## EXPERIMENTAL RATIONALE FOR METHODS OF REGULATING CELLULAR UPTAKE AND CYTOTOXICITY OF FLUORESCENT QUANTUM DOTS AND THEIR CONJUGATES WITH ANTITUMOR COMPOUNDS FROM THE GROUP OF PENTACYCLIC TRITERPENOIDS



A



B

A – Labeling of C6 glioma cells with quantum dots (20 nM, left) and nanoplates (0.2 nM, right), nuclei stained with Hecht 33342; B – Effect of nanoparticle conjugates with betulinic acid (QD\_Bet) and reference nanoparticles (QD) at a dose of 0.02  $\mu$ M on the growth of C6 glioma cells (48-hour culturing); \*  $p < 0.05$  compared to control group; \*\*  $p < 0.05$  compared to corresponding QD\_Bet group

### Development Description

It was found that cellular uptake of semiconductor fluorescent nanoparticles can be regulated by changing their geometric shape, introducing functional chemical groups in the shell composition, changing the concentration of nanoparticles and duration of cultivation of cells with nanoparticles. It was shown that betulinic acid derivative significantly enhances the binding of semiconductor nanoparticles (quantum dots) with negatively charged groups in the shell to cells. Conjugates of quantum dots and betulinic acid derivative exhibit antiproliferative and/or cytotoxic effects against C6 glioma cells.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Semiconductor fluorescent nanoparticles are more stable and brighter fluorophores than traditional fluorescent proteins.

### Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Chemical Technologies and Materials” for 2016–2020, subprogram “Biologically active substances”, task 2.51 “Regulation of cellular uptake and cytotoxicity of fluorescent quantum dots and their conjugates with antitumor compounds from the group of pentacyclic triterpenoids”.

### Field of Application

Pathophysiology, biopharmacy.

### Contact Information of Organization-Developer

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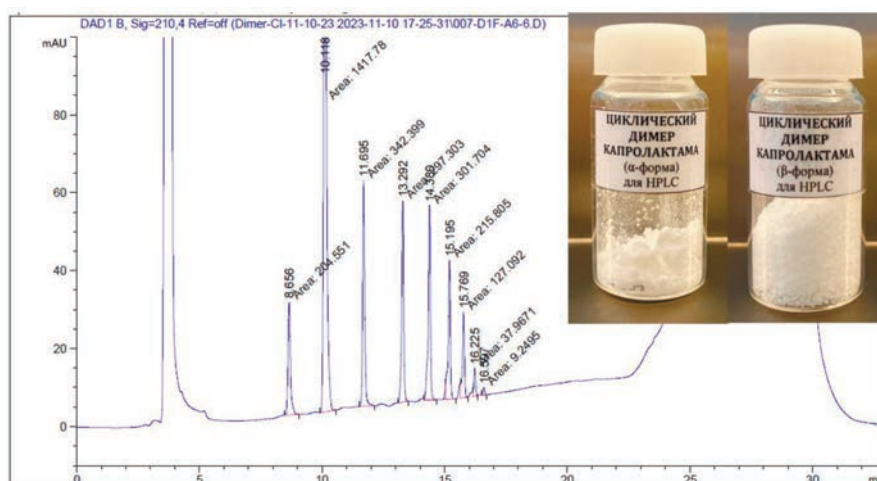
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Republican Research Unitary Enterprise  
“Institute of Biochemistry of Biologically Active Compounds  
of the National Academy of Science of Belarus”

## METHOD OF PREPARATION OF A STANDARD SAMPLE OF CYCLIC CAPROLACTAM DIMER AND ITS DETERMINATION



### Development Description

Chromatographically pure sample of cyclic caprolactam dimer ( $\alpha$ - and  $\beta$ -forms), which is suitable as a standard for the determination of low molecular weight compounds in polyamide 6 (PA 6). For this purpose, the method of high-performance liquid chromatography (HPLC) was used, as well as additionally, the method of its determination using HPLC in finished products, semi-finished polyamide 6 and in samples of extraction waters during the production of PA 6. The development allows systematic control over the production process, which reduces the amount of waste, the risk of damage to processing equipment and financial costs in the production of PA 6. The development allows additional quality control before shipment to the consumer, which increases the competitiveness of domestic products based on polyamide 6.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The development has been created at a high scientific and technical level and has no analogues in the world.

### Intellectual Property Protection

Development rights are owned by JSC “Grodno Azot” (according to contract No. 302/06-23 of 06.02.2023, JSC “Grodno Azot” is the customer for the development). Notification on creation of service object of industrial property right with further patenting of the development was formalized.

### **Name of the programme, subprogramme, project, business contracts under which the development was obtained:**

– Contract with JSC “Grodno Azot” branch “Khimvolokno Plant” No. 302/06-23 dated 06.02.2023 “Development of a method for obtaining a standard sample of cyclic caprolactam dimer and a method for its determination”;

– Contract with JSC “Grodno Azot” branch “Khimvolokno Plant” No. 302/44-23 dated 15.09.2023 “Quantitative determination of the mass fraction of low molecular weight compounds (dimer, trimer, tetramer, pentamer, hexamer, heptamer, octamer, nanomer) in polymer samples”.

### Field of Application

Chemical and polymer industry.

### Contact Information of Organization-Developer

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State Scientific Institution  
“Institute of Radiobiology of the National Academy of Sciences of Belarus”

## MICROBIOLOGICAL METHOD OF REDUCING RADIONUCLIDE BIOAVAILABILITY IN SOILS



### Development Description

The advanced forms of complex microbial fertilizers and the instructions for their application towards reducing the transfer of radioactive cesium and strontium isotopes from soil to plants were developed and tested. EM-1 microbial fertilizer (in liquid form) is used for the pre-plant treatment of soils and soil dressings throughout the whole vegetation period. Bokashi soil conditioner (powdered) can be used for soil improvement either independently or in combination with organic fertilizers.

Experiments demonstrate that the use of EM-1 complex microbial fertilizer containing yeast fungi and the strains of lactic and purple bacteria together with Bokashi EM-1-derived soil conditioner significantly reduces biologically available forms of  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in the treated soil and their accumulation in plants. The experimental results present the scientific basis for the development of new-generation countermeasures in the crop-growing industry consistent with the principles of organic farming.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed advanced forms of complex microbial fertilizers and their application methods are consistent with the principles of organic farming. In addition to reducing the accumulation of the main dose-contributing radionuclides in plants, their use has a favourable effect on soil productivi-

ty and increases its resistance against adverse environments. The systemic application of the developed complex microbial fertilizers contributes to soil remediation improving the fertility of degraded and technogenically disturbed soils. The scientific and technical level corresponds to the best world alternative developments.

#### Intellectual Property Protection

Technical Specification “Soil-improving additive “Bokashi OP” TR BY 100262624/012-2020.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Cooperation agreement between EM Research Organization (Japan) and Institute of Radiobiology of the National Academy of Sciences of Belarus dated 01.01.2012 (Supplementary Agreement No. 6 dated 04.01.2018).

#### Field of Application

Agricultural production in radiation-affected areas.

#### Contact Information of Organization-Developer

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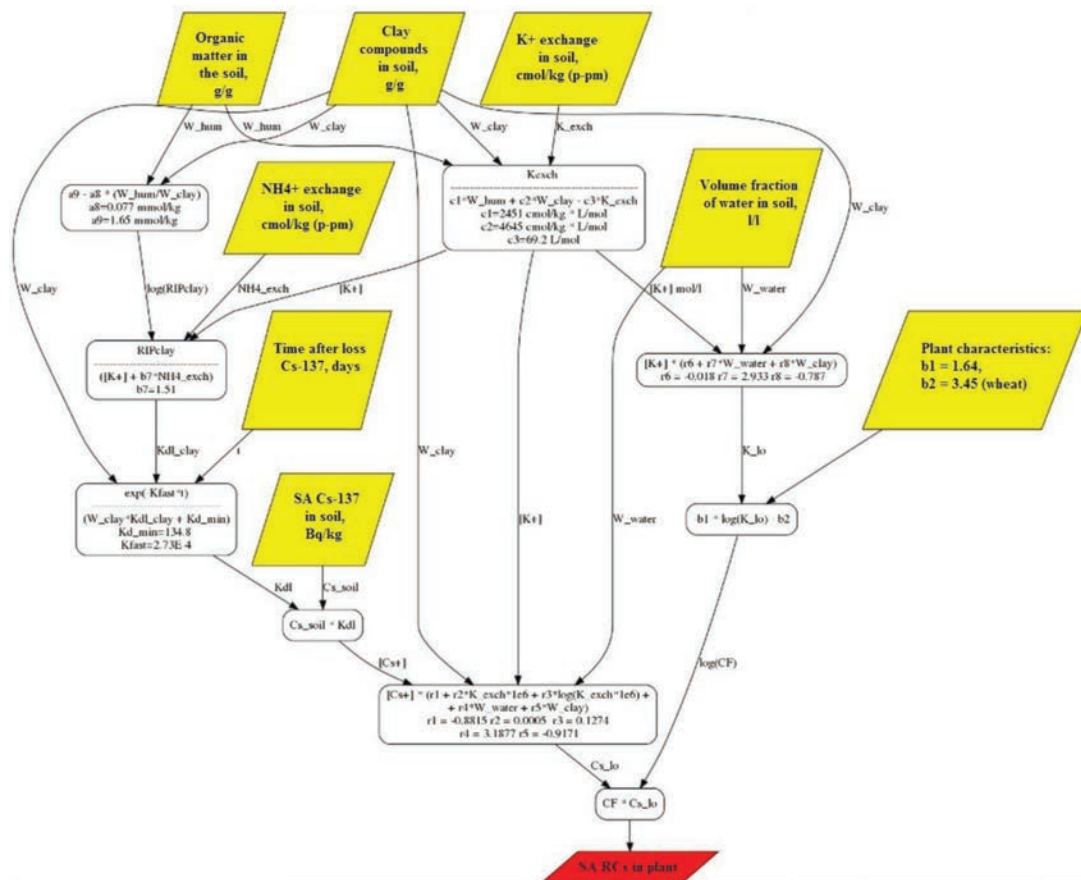
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State Scientific Institution  
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## <sup>137</sup>Cs SOIL-TO-PLANT TRANSFER MODEL FOR THE REMOTE RADIOECOLOGICAL CONSEQUENCES FOLLOWING TECHNOGENIC EMISSIONS



### Development Description

A semi-mechanistic model of <sup>137</sup>Cs soil-to-plant transfer supplemented with a suite of tools and integrated into a decision support system is intended for the prediction of cesium accumulation in agricultural crops long after a nuclear or radiological accident followed by emission of technogenic radionuclides into the environment. The model differs from similar existing solutions in that it takes into account hydrological variability and deviations of weather conditions from the climatic norm.

It also takes into account the variance of biological availability of radioactive cesium in soils in the course of several decades following its emission into the environment. The model is based on the processes and phenomena, such as distribution of  $\text{Cs}^+$  and  $\text{K}^+$  in the soil absorbing complex, soil solution and selective adsorption sites in interlayer spaces of clay minerals, cation diffusion and its effect on the rhizosphere, and the cation uptake by plants from the rhizosphere.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

A semi-mechanistic model and an associated toolkit for the prediction of cesium contents in agricultural crops takes into account such factors, as humidity and mechanical composition of soils, concentrations of cesium, potassium, ammonium and organic matter in soils, and the time after the radioactive fallout. This helps to ensure reliable predictions of radioactive contamination of agricultural products and make efficient managerial decisions on the organisation of agricultural production in the affected territories with due regard to the wide range of factors and weather-climate conditions. The model corresponds to the best of the world's similar products by most of its characteristics, whereas it well surpasses them by its individual features (i. e. account for hydrological and climatic conditions).

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Programme “Environmental Management and Ecology”, 2016–2020; subprogramme “Radiation and Natural Systems”; task 3.17 “Assess the impact of inter-annual variances of hydrological and temperature conditions on the physical and chemical occurrence forms of radionuclides and heavy metals in soils, as well as on their uptake by plant organisms”, state registration number 20160508, R&D level is “world-class”.

Field of Application

Decision support systems in agricultural radiology; assessment of environmental impact of nuclear and radiological facilities.

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State Scientific Institution  
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## RISKAgro – ELECTRONIC INTERACTIVE HANDBOOK FOR THE CONTAMINATION RISK ASSESSMENT OF RADIONUCLIDES FOR AGRICULTURAL PRODUCTS ABOVE THE ESTABLISHED FOOD SAFETY STANDARDS



### Development Description

RISKAgro is a specialized C#-programmed software designed for a) prediction of contamination levels in crops (grains, vegetables, root and tuber crops), dairy and meat products, as well as animal feeds, and b) risk assessment of producing agricultural products above the existing permitted levels for  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  in radionuclide-affected areas. The programming algorithm is based on the risk assessment methodological approach, which considers both radionuclides,  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ , simultaneously, using a risk matrix to identify and rank risks and risk criteria to evaluate and measure their significance. The risk assessment procedure takes into account the

likelihood of the exceeding permissible levels of radionuclides in each type of product selected by the user.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

It has no analogues. For the first time, it suggests a new methodological approach for assessing the risk of non-compliance of the produced agricultural foodstuffs to the regulatory requirements, taking into account not only one, but both radionuclides ( $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ ) simultaneously.

**Intellectual Property Protection**

None. The software is registered in the State Register as an information resource (certificate number 5872437494, State registration date: 02/14/2024)

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

2019–2022 Programmes on Joint Actions of the Union State of Russia and Belarus on Public Protection and Remediation of Areas Affected by the Chernobyl NPP Disaster, activity 1 “Development of new approaches to contamination minimization technologies in agricultural sector”, task 1.1.5 “Risk assessment in crop and animal production in radionuclide-contaminated areas”.

**Field of Application**

Agroindustrial complex and food safety, nuclear energy, potential end-users: public authorities, agricultural enterprises and businesses of all forms of ownership operating in the territory of radioactive contamination.

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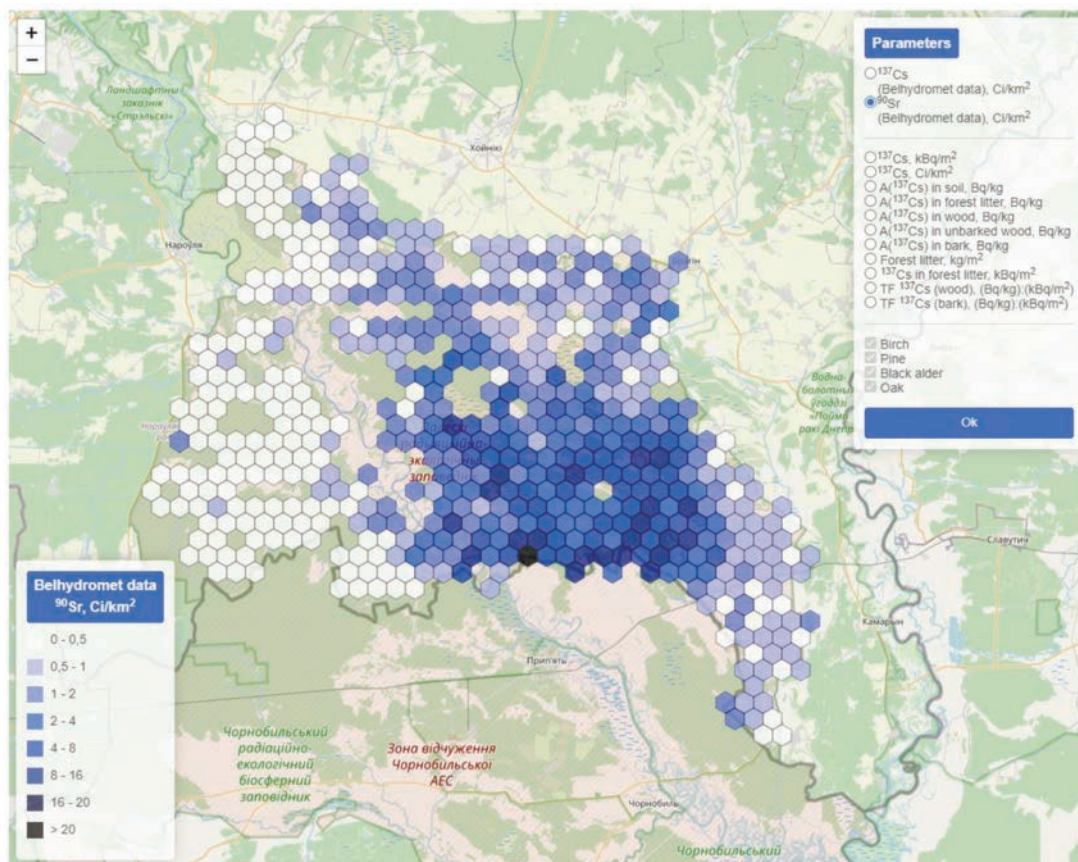
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State Scientific Institution  
“Institute of Radiobiology of the National Academy of Sciences of Belarus”

INFORMATION DATABASE “LEVELS OF RADIOACTIVE  
CONTAMINATION OF THE MAIN FOREST-SPECIES  
WOOD, SOIL AND FOREST LITTER IN HIGH-LEVEL  
CONTAMINATED TERRITORIES”



### Development Description

Information database “Levels of radioactive contamination of the main forest-species wood, soil and forest litter in high-level contaminated territories” comprises 8 tables and 10 “one-to-many”-type relationships. The database is operated via the web application written in the C# language for .Net 6 platform, available at [radioecology.by](http://radioecology.by). For security reasons, the database can be accessed only by registered users and with an access code provided by the administrator.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The database has no analogues.

**Intellectual Property Protection**

Certificate of state registration of information resource № 5342437639 dated 12.03.2024 Database “Levels of radioactive contamination of wood of the main forest-forming species, soil and forest litter in areas with high levels of radioactive contamination”.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

2019–2022 Programmes on Joint Actions of the Union State of Russia and Belarus on Public Protection and Remediation of Areas Affected by the Chernobyl NPP Disaster, activity. 2 “Risk minimization in the event of transboundary transfers of radioactive elements in emergency situations in radioactively contaminated territories of the Union State’s Member States and enhancement of response capacity and efficiency in such events”, task 1.2.4 “Assessment of radiation content in wood of the main forest-forming species in the areas of high-level radioactive contamination, control of compliance with the republican permissible levels of radionuclide content, assessment of contaminated wood contribution to the total contamination of forest combustible materials”.

**Field of Application**

Forestry, manufacturing and processing industry.

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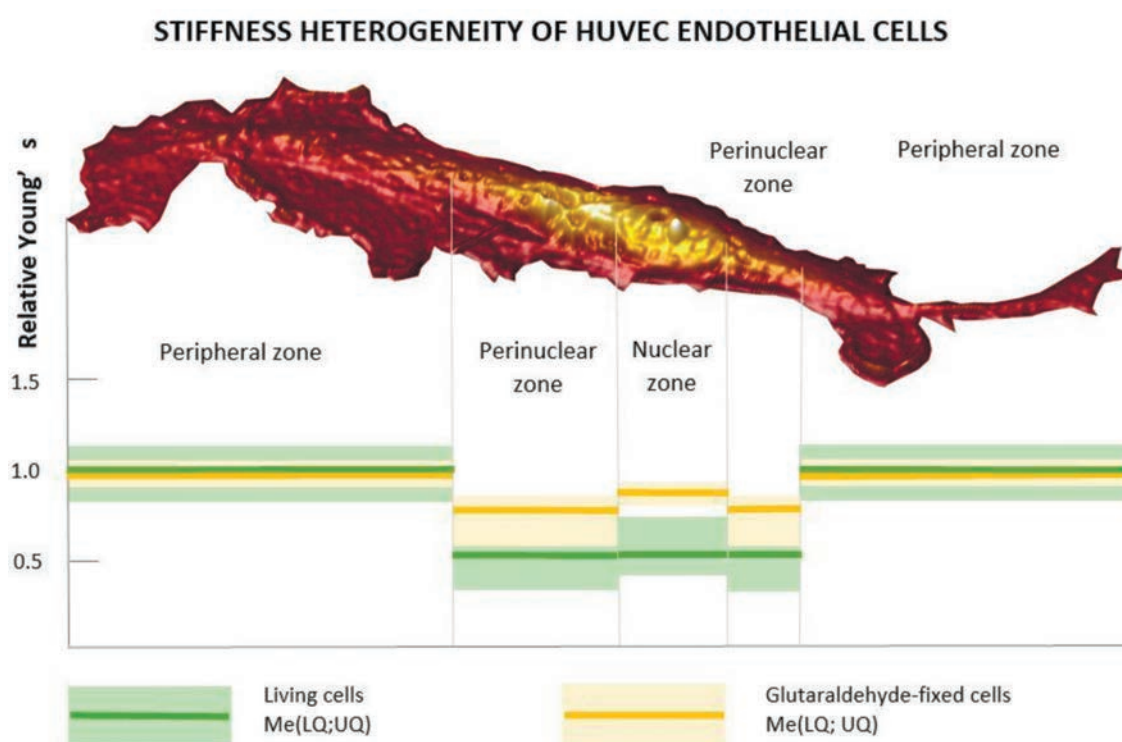
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State Scientific Institution  
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## HETEROGENEITY OF NANOMECHANICAL PROPERTIES OF CELLS



### Development Description

Atomic force microscopy (AFM) in the mode of nanomechanical mapping was used to establish the dependence of the nanomechanical parameters (elasticity, adhesion) of the endothelial cell surface on nuclear, perinuclear, and peripheral regions. The perinuclear zone was found to be softer than other cellular regions. Heterogeneity in the mechanical properties of cells at the nanoscale may play a crucial role in regulating endothelial functions in blood capillaries, including endothelial dysfunction.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The results of the comparative study of nanoarchitecture and nanomechanical properties of the surface of living and chemically fixed endothelial cells (HUVEC line) indicate the fundamental nature of the heterogeneous

distribution of mechanical properties over the cell surface. The data were obtained in PeakForce QNM mode with a significantly smaller indentation depth of about 100 nm, in contrast to classical force spectroscopy, where the indentation depths could reach 400 nm. Due to the small indentation depth, the results obtained, which mainly correlate with the spatial structure of the cortical actin cytoskeleton, are potentially applicable to uncover the mechanisms of interaction of nanosized particles with cells.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

BRFFR research project “CD109-regulated mechanical properties of endothelial cells” 2020–2021, no. M20KI026.

**Field of Application**

Nanomedicine, biophysics.

**Contact Information of Organization-Developer**

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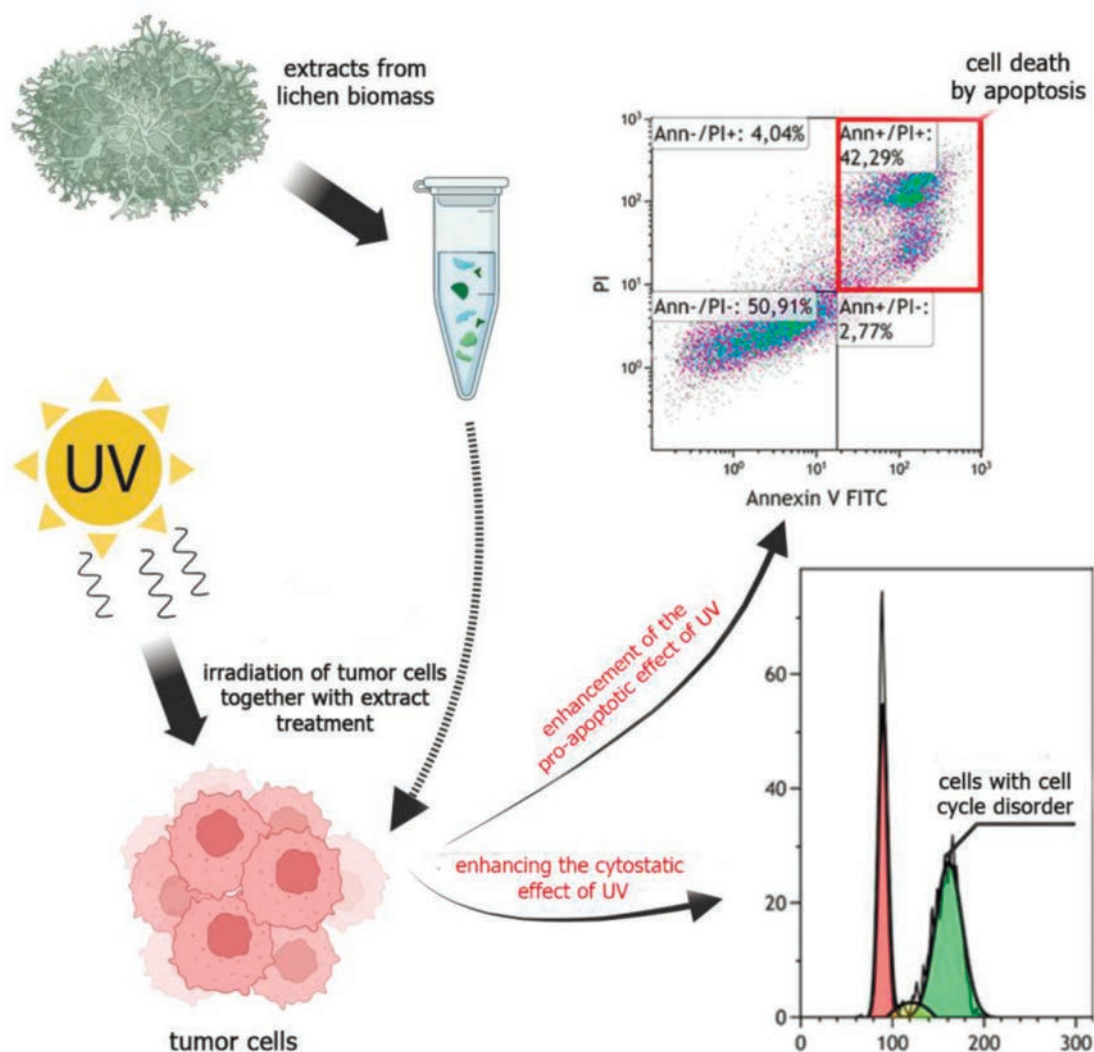
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State Scientific Institution  
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## CYTOTOXIC AND PHOTSENSITIZING EXTRACTS OF LICHENS IN RELATION TO CULTURES OF HUMAN TUMOR CELL



### Development Description

The experimental samples of 11 lichen extracts capable of pronounced suppression of tumor viability were identified. The antitumor cytotoxic, cytostatic and photosensitizing effects of extracts were studied and proven using MCF-7 cell line – mammary ductal adenocarcinoma, which scientifi-



cally substantiate the prospect of using lichen extracts as antitumor agents with a wide range of action.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The development is new for the Republic of Belarus and has no analogues. For the first time, an experimental justification has been given for the possibility of using lichen extracts to modify the effects of ultraviolet radiation.

**Intellectual Property Protection**

Khramchankova V. M., Matveyenkau M. V. Photoprotective biologically active additive for cosmetic compositions. Patent of the Republic of Belarus No. BY23327. – Publ. 28.12.2020.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific Research Programme “Natural Resources and Environment” 2021–2025, sub-programme “Radiation and Biological Systems”, task 3.03 “Develop methods of increasing adaptive capabilities of the body and reducing negative impacts of anthropogenic and natural factors”, project 3 “Mechanisms for the implementation, control and correction of viability of stable and tumor cells under ultraviolet exposure and with using lichen extracts”, state registration number 20210254.

**Field of Application**

Medicine, pharmaceuticals.

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State Scientific Institution  
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## REPRODUCTIVE SYSTEM AS A DAMAGING-ACTION MARKER OF RF ELECTROMAGNETIC RADIATION. DEVELOPMENT OF PROTECTION AND CORRECTION METHODS



### Development Description

Experimentally obtained data reveals that the exposure to low-intensity electromagnetic radiation (1745 MHz, 8 h/d, EFD 0.26–20.00  $\mu\text{W}/\text{cm}^2$ ) can be the cause of certain changes in the normal functioning of the male reproductive system, the nature and severity of which vary depending on the duration of exposure and the age of test animals. The most apparent alterations can be observed in the pubertal male rats of 57–59 days of age and are manifested in early spermiogenesis, meaning premature puberty involving degrading viability of mature germ cells. The experiments establish that the chronic exposure to EMR coming from a mobilephone (MP EMR) has a negative impact on the birth rate and reproductive system of males throughout three generations. The MP EMR is proved to be the factor with the ability to cause long-term changes in the reproductive system of males born of irradiated parents, suggesting the exposure to electromagnetic radiation generated by the sources of cellular transmission has a transgenerational effect. For the efficient correction and recovery from the MP EMR-associated damages occurred in the reproductive system of the exposed male rats, a post-treatment drug has been developed based on

O-Acetyl-L-carnitine, vitamin C, fructose and sodium succinate, the use of which triggers the numbers of sperm cells (stimulation of spermiogenesis), enhances the viability of epididymal spermatozoa, normalises sperm cell production and the androgen status of irradiated animals.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Unknown to have any prior precedents, a comprehensive analysis of the morphofunctional characteristics of the male-rat reproductive system is a first time ever to be carried out at different stages of development (antenatal and postnatal periods) and across several generations under the effect of chronic exposure to low-intensity electromagnetic radiation generated by a mobile-communication device. The findings of this study expand the existing knowledge of the phenomenon and contribute to a deeper understanding of the mechanisms and effects of low-intensity electromagnetic exposure, potentially serving as the basis for developing relevant hygienic standards and scientifically grounded recommendations on how to improve the quality of life under the modern-time technogenic burden. The revealed high efficiency of the use of the biologically active substances complex indicates the prospects of its use for the protection and restoration of the male reproductive system, as a radioprotector, when exposed to low-intensity electromagnetic radiation of the decimeter range. The proposed formulation of biologically active substances can be used to develop new effective means of preventing diseases of the male reproductive system. The drug, when used in recommended dosages, is characterized by the absence of side and toxic effects. The development is new for the Republic of Belarus and is unique in the presence of global analogues. The research results can also be integrated into medical and biological curricula and subject courses of higher-education establishments. The entirety of the results provides a significant contribution in terms of addressing one of the most relevant present-time scientific challenges associated with radiobiology of non-ionizing radiation sources.

#### Intellectual Property Protection

Chueshova, N. V., Kozlov, A. E., Cheshik, I. A. Radioprotective drug. Patent of the Republic of Belarus No. BY23292. – Publ. 30.12.2020.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Programme “Environmental Management and Ecology”, 2016–2020; subprogramme 3 “Radiation and Natural Systems”; task 3.06 “Study of the long-term effects of prolonged electromagnetic exposure from a 1800 MHz mobile device and a 2.45 GHz WiFi device, and evaluation of

the biological efficiency of antioxidants and other bioactive agents for the sake of enhancement of protective properties of the EMR exposed organism”, state registration number 20160214, R&D level is “world-class”.

#### **Field of Application**

Medicine and pharmacy, environmental management and environmental protection, higher-educational curricula.

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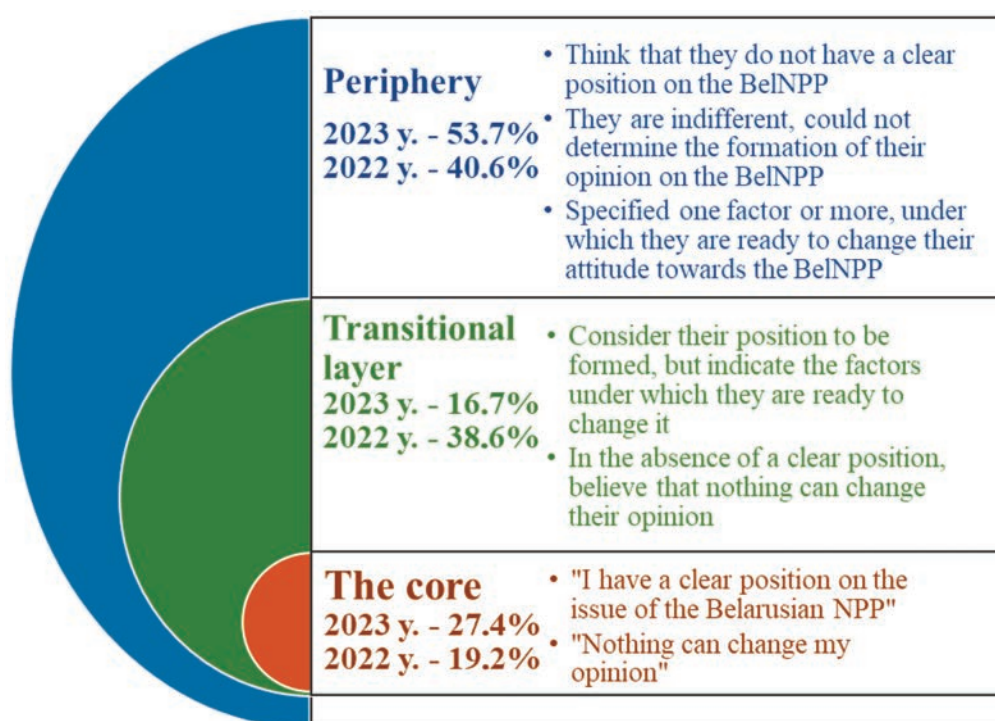
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DEPARTMENT  
OF HUMANITIES AND ARTS

State Scientific Institution  
“Institute of Sociology of the National Academy of Sciences of Belarus”

## METHODOLOGY FOR IDENTIFYING THE STRUCTURE OF POPULATION GROUPS ALLOCATED IN RELATION TO THE BELARUSIAN NPP (SUPPORTERS, OPPONENTS, DIFFICULT) AND PREDICTING THEIR BEHAVIORAL PRACTICES IN THE FUTURE



### Development Description

Author's methodology for identifying the structure of population groups allocated in relation to the Belarusian NPP (supporters, opponents, found it difficult) and predicting their behavioral practices in the future. This technique allows typologizing the representatives of each group on the stability of the voiced position (formation of opinion) and determining the potential for further reduction of share of NPP opponents in the Belarusian society, i.e. identifying the conditions for the transition of as many of their representatives as possible from one group (opponents and those who found it difficult) to another (supporters).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues):**

The key advantage of the presented methodology is the typology of the surveyed population according to such attribute as stability of the position towards the Belarusian NPP, which allows building awareness-raising work taking into account the specifics of each group of the population (supporters, opponents, hesitators) identified in the course of the research, based on their social expectations, psychological and behavioral reactions to the changes taking place in the energy sector of the country. For the first time in Belarus, by means of long-term (2005–2023) sociological monitoring, there is an opportunity to see in dynamics the state of public opinion in Belarus about the development of nuclear energy and the “Belarusian NPP” project, and to catch in time new trends and problems in the issues under study, to prevent possible social upheavals and reduce social tension, if necessary.

#### **Intellectual Property Protection**

Copyright in accordance with paragraphs 19, 21 of chapter 6 of the Agreement with the State Scientific Institution “Joint Institute for Energy and Nuclear Research – Sosny” of the National Academy of Sciences of Belarus No. 2021-1/B of 25.06.2021.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State program “High-Tech Technologies and Engineering” for 2021–2025, subprogram 3 “Scientific support for the efficient and safe operation of the Belarusian nuclear power plant and promising areas for the development of nuclear energy”, task “Conduct sociological monitoring of public opinion of the population of the Republic of Belarus in order to form a positive attitude to nuclear energy”, activity 8 “Information and analytical support for the development of nuclear energy in the Republic of Belarus”.

#### **Field of Application**

Social sphere and society.

#### **Contact Information of Organization-Developer**

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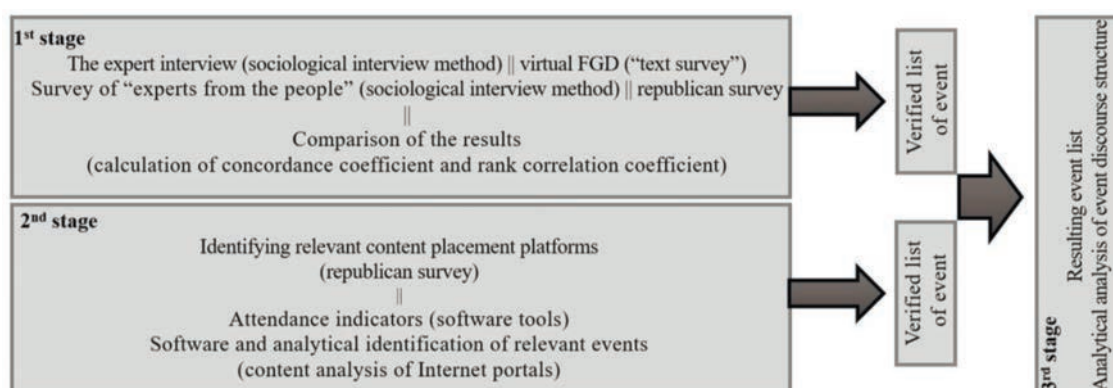
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State Scientific Institution  
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## METHODOLOGICAL STRATEGY FOR IDENTIFYING INFORMATION EVENTS-TRIGGERS



### Development Description

To identify key conditionally neutral information events it is proposed to use a research strategy of combining methods of sociological research, which includes both traditional methods of collecting sociological information and technical and technological software capabilities that have become available in the conditions of digitalization, as well as involves multi-stage verification of sociological information. This tactic is implemented in order to achieve a triangulation effect (triangulation of data and methods), which increases the validity of the obtained patterns by reducing the relative limitations that each method has in one way or another.

In the temporal dimension, the strategy of combining methods in the direction of highlighting relevant events and analyzing their interpretive environment represents the implementation of three stages. This implies the initial implementation of the synthesis of traditional methods (expert survey of the professional community, implemented by the method of in-depth interviews, with its verification by means of the designed virtual focus group discussion, as well as the survey of “experts from the people”, implemented by the method of in-depth interviews and verified by the results of a mass survey of the population; the fairness of the correlation of assessments and opinions of the two expert groups was additionally verified by calculating the coefficients of concordance and rank correlation). At the second stage – program technical and technological solutions for highlight-

ing events in the Internet space on the pages of portals, verified analytically and by the data of the mass survey of the population.

At the third stage – comparison of the two obtained sets of events, development of the resulting list and direct selection of discourses formed by them with their subsequent analysis. In the information dimension there will be a parallel implementation of the described procedures, i.e. the collection of information at the first and second stages is carried out conditionally independently within the framework of the convergence strategy.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The key advantage is multistage verification of sociological information as a promising set of research procedures of modern representative sociological research, realized in the course of stage-by-stage implementation of the methodological strategy based on the combination of qualitative and quantitative methods of data collection, calculation of additional coefficients, use of technical and technological methods of data collection, calculation of additional coefficients, use of technical and technological methods of data collection.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Economy and Humanitarian Development of Belarusian Society” 2015–2020, subprogram “Sociology and Philosophy”, section “Sociology”, scientific research “Development of a set of technologies to effectively counteract destabilizing factors of the modern world to ensure sustainable development of the Republic of Belarus” (No. GR 20161304).

Field of Application

Scientific research and development, information technologies, communications, social sphere, education.

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State Scientific Institution  
“Institute of Philosophy of the National Academy of Sciences of Belarus”

## BELARUSIAN ETHNOPHILOSOPHY IN THE SYSTEM OF NATIONAL CULTURE



### Development Description

For the first time in humanities, a systematic reconstruction of the key themes, ideas and concepts of Belarusian folk philosophy has been accomplished, with the use of modern methodologies of philosophical hermeneutics, cultural semiotics, comparative mythology and religious studies; the ideological, cognitive and value foundations of the traditional culture of Belarusians have been revealed, their role and significance for the Belarusian national philosophy and culture have been exposed. The traditional ideas of Belarusians about the origin and structure of the Universe, the multidimensional sacred sphere of human experience, God and the divine world have been reconstructed. The project has no direct global analogues.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

In international practice, this is the first attempt in Western scholarship to study the ethnophilosophy of the people belonging to European culture.

Ethnophilosophy traditionally explores the ideological foundations of modern illiterate cultures. The principal novelty of the project is that it focuses on the study of one of the traditional European cultures. For Belarusian humanities, the novelty of the project lies in the fact that the oral folk culture is considered as the outcome of a comprehensive understanding and interpretation of the world by its creator, i.e., the people. It is an attempt to reconstruct the traditional Belarusian worldview system and its evaluation as the national intellectual prehistory, on the basis of a methodical reconstruction of its authentic worldview, cognitive foundations, social modalities and axiological concepts.

#### Intellectual Property Protection

Traditional Worldview of Belarusians. In 5 volumes. Volume 1. Cosmology. Volume 2. Sphere of the Sacred. Folk Theology / National Academy of Sciences of Belarus, Institute of Philosophy; compilation and editing: I. Dubianieckaja, S. Sańko; authors: T. Valodzina [et al.]; illustrations: M. Chrapavicki; Idea of the project: V. Gusakov; Project Coordinator: A. Lazarevič. – Minsk: Bielaruskaja navuka, 2023.

A little closer to the Sun, a little further from the Moon: Belarusian folk philosophy / T. Valodzina[et al.]; compilation and editing: I. Dubianieckaja, S. Sańko; National Academy of Sciences of Belarus, Institute of Philosophy.– 3rd edition. – Minsk: Bielaruskaja navuka, 2023. – 481 pp.

The collective monographs are subjects to copyright.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

A separate project of fundamental and applied scientific research “Key Ideas and Concepts of Belarusian Ethnophilosophy”, 2022–2023.

SRP “Society and Humanitarian Security of the Belarusian State” 2021–2025, subprogram “Philosophy”, task 4.02 “Spiritual Culture as the Basis for Sustainable Development and Humanitarian Security of the Belarusian Society”.

#### Field of Application

Social sphere.

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State Scientific Institution  
“Institute of Economics of the National Academy of Sciences of Belarus”

## ORGANIZATIONAL AND LEGAL INSTRUMENTS FOR COMMERCIALIZATION OF THE RESULTS OF SCIENTIFIC AND TECHNICAL ACTIVITIES



### Development Description

For the first time, a comparative analysis of the intellectual property market development of the Republic of Belarus and the People's Republic of China was carried out through patent activity monitoring; directions and recommendations were developed for improving the legal as well as organizational and economic instruments for the commercialization of the results of scientific and technical activities in the Republic of Belarus, taking into account the innovative practices of the People's Republic of China for the commercialization of the resulting developments.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The state registration number of the research project is 20171927, the level of development to which the work corresponds to is “world-class”.



### Intellectual Property Protection

Improving the mechanism for commercialization of innovations in the Republic of Belarus, taking into account the experience of China / V. I. Belsky [et al.]; under scientific ed. of V. I. Belsky, D. V. Mukha. – Minsk: Belarus. Navuka, 2019. – 357 p.

The collective monograph is subject to copyright.

### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Plan of scientific research and development for national, industrial purposes aimed at scientific and technical support of the activities of the National Academy of Sciences of Belarus in 2017 approved by the Chairman of the Presidium of the National Academy of Sciences of Belarus V. G. Guskov on 01.03.2017, project “Development of scientifically based recommendations for improving the mechanism for commercialization of the results of scientific and technical activities in the Republic of Belarus based on the experience of the People’s Republic of China”.

### Field of Application

The results of the study found their application in the activities of the Administration of the President of the Republic of Belarus and the apparatus of the National Academy of Sciences of Belarus.

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State Scientific Institution  
“Institute of Economics of the National Academy of Sciences of Belarus”

## MACROECONOMIC INSTRUMENTS IN THE BELARUSIAN INSTITUTIONAL MODEL



### Development Description

For the first time the assessment of the shadow economy impact on the country's financial sector balance was carried out, the system of institutional and legal instruments for improving monetary policy and risk management of the banking system was developed, the mechanism for attracting foreign direct investments was proposed taking into account existing external and internal threats aimed at activating stock market instruments.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The state registration number of the research project is 20160259, the level of development to which the work corresponds to is “world-class”.

### Intellectual Property Protection

Macroeconomic instruments in the Belarusian institutional model / A. I. Luchenok [et al.]; under scientific ed. of A. I. Luchenok; Institute of

Economics of the National Academy of Sciences of Belarus. – Minsk: Belarus. Navuka, 2018. – 283 p.

The collective monograph is subject to copyright.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific Research Program “Economy and humanitarian development of Belarusian society”, 2016–2020; subprogram “Economics”; task 2.02 “Research of theoretical and methodological foundations and development of effective financial policy concept in the Republic of Belarus”.

**Field of Application**

The results of the study were used in the activities of the Administration of the President of the Republic of Belarus, the Ministry of Antimonopoly Regulation and Trade of the Republic of Belarus, the Ministry of Agriculture and Food of the Republic of Belarus, the Ministry of Economy of the Republic of Belarus, and State Institution “National Agency of Investment and Privatization”.

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State Scientific Institution  
“Center for Research of Belarusian Culture, Language and Literature  
of the National Academy of Sciences of Belarus”

## “HISTORICAL DICTIONARY OF THE BELARUSIAN LANGUAGE” IN 37 VOLUMES



### Development Description

“Historical Dictionary of the Belarusian Language” in 37 volumes is the only lexicographic description of the vocabulary of the Belarusian language of the 14–18 centuries in national and foreign science. The subject of lexicography is the vocabulary recorded in contracts, charters, chronicles, chronographs, military and chivalric romances and novellas, memoirs, publicistic, scientific and religious works created in the Old Belarusian literary language.

The edition is a reliable source of scientific and popular research and development in the humanities. The materials of the dictionary contribute to the deepening of scientific provisions on the internal and external history of the Belarusian language, its relations with other Slavic and non-Slavic languages in different chronological periods, its role in the formation of the Belarusian ethnic group and the strengthening of the Belarusian state-

hood. They are important for identifying the features of the lexical system of the Belarusian language at all stages of its development; for solving the problem of continuity between Old Belarusian and modern Belarusian. The preparation of the “Historical Dictionary of the Belarusian Language” had a positive impact on the development of the theory and practice of Belarusian and foreign historical and modern lexicography, historical lexicology and phraseology, historical stylistics, historical onomasiology, linguotextology, historical word formation, as well as on the development of other areas of modern humanities knowledge. The dictionary is used in the teaching of historical and linguistic disciplines in higher and secondary educational institutions; in the development of new types of dictionaries of Belarusian and other Slavic and non-Slavic languages; in the compilation of appendices and subject indexes for the publication of ancient handwritten and printed texts; in the implementation of interdisciplinary and international projects of linguo-historical, linguo-cultural, linguo-theological, ethnolinguistic content, when conducting educational activities aimed at popularizing the written heritage, scientific achievements, activities of employees of scientific research institutions, etc.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The dictionary confirms the importance of historical and cultural heritage as the evidence of the national and cultural identity of Belarusians, contributes to its preservation, popularization in the Republic of Belarus and foreign countries, promotes public awareness of the intellectual heritage of our ancestors, increases the prestige of humanities knowledge in modern society; strengthens the status of Belarusian linguistics and Belarusian humanities at the international level. The type of intellectual property object is a work of science.

#### **Intellectual Property Protection**

The 37<sup>th</sup> volume of the “Historical Dictionary of the Belarusian Language” published in 2017 (as well as the previous volumes) is subject to copyright.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

The 37<sup>th</sup> volume was prepared within the framework of the State Research Program “Economics and Humanitarian Development of the Belarusian Society”, 2016–2020; subprogram “Belarusian Language and Literature”.

### **Field of Application**

Linguistics, history, literary studies, law, archival studies, bibliography, ethnography, local history, science studies, etc.

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DEPARTMENT  
OF AGRARIAN SCIENCES



**Republican Unitary Enterprise “Research and Practical Center  
of the National Academy of Sciences of Belarus for Arable Farming”**

## **SPRING BARLEY VARIETY RAIDER**



### **Development Description**

The variety of spring barley is for feed use. It has been included in the State Register of the Russian Federation for the Central (3) region since 2019. It is recommended for cultivation in Ivanovo region. The weight of 1000 grains is 43–52 g. The average yield in the Central region is 35.1 c/ha. In Ivanovo region, the increase to the Vladimir standard was 6.5 c/ha with the yield of 33.1 c/ha. The maximum yield – 61.3 c/ha was obtained in 2017 in Tula region. The variety is mid-ripening, the vegetation period is 74–93 days; the variety ripens 1–3 days later than the Vladimir and Elf standards and 2–3 days earlier than the Yaromir and Ataman varieties.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Lodging and drought resistance is at the level of the standard varieties Vladimir and Yaromir. The protein content is 9.4–14.6 %, starch is 58.7 %, protein collection per hectare is 5.7 centners, starch is 25.0 centners. It has good cereal particles, thus: the uniformity of the resulting cereal is 91.7 %,

the yield of pearl barley is 56.2 %, the organoleptic assessment of the porridge is 4.4 points. The variety is resistant to stem rust, powdery mildew, rhynchosporium, practically resistant to loose smut, and moderately susceptible to root rot. Under field conditions of the region it was moderately affected by helminthosporium and net blotch.

#### Intellectual Property Protection

Spring Barley Variety Raider. Patent of the Russian Federation No. 11361. Patent in the Republic of Belarus No 576 from 25.10.2019.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Agricomplex – sustainable development”, 2014–2015; task “Create the variety of spring feed barley with the potential yield of 62–65 centners per hectare increasing the standard by 5–7 % in terms of yield and resistant to lodging, tolerant to main diseases, with high feeding qualities; improve the cultivation technology of new varieties of feed barley”.

#### Field of Application

Agriculture, providing the republic with food and feed barley grain.

#### Contact Information of Organization-Developer

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**Republican Unitary Enterprise “Research and Practical Center  
of the National Academy of Sciences of Belarus for Arable Farming”**

## **SPRING WHEAT VARIETY LADIA**



### **Development Description**

The variety of spring wheat is for food use. It is included in the State Register of the Russian Federation for the North-West region (2), the Central region (3) and the Volga-Vyatka region (4). It is recommended for cultivation in Kaliningrad, Vladimir, and Kirov regions. The bush is semi-erect. The plant is medium-sized. The grain is colored. The weight of 1000 grains is 36–45 g. The average yield in the North-West region is 27.4 c/ha, in the Central region – 33.5 c/ha and in the Volga-Vyatka region – 36.3 c/ha. In Kirov region the increase to the Margarita standard was 2.7 c/ha and in Kalinigrad region – 4.0 c/ha to the Trizo standard with the yield of 43.7 and 38.1 c/ha respectively. The maximum yield – 71.6 c/ha was obtained in 2017 in Vladimir region. The variety is mid-ripening, the vegetation period is 81–104 days; the variety ripens simultaneously with the Trizo variety.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

It is resistant to lodging. Drought resistance is at the level of the Trizo standard. Good baking qualities. Valuable wheat. It is moderately resistant to head smut. Under field conditions it is slightly affected by powdery mildew and moderately affected by root rot.

**Intellectual Property Protection**

Spring Wheat Variety Ladia. Patent of the Russian Federation No. 9458. Patent in the Republic of Belarus No 578 from 25.10.2019.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program "Agricomplex", 2013–2015; subprogram "Agricomplex – sustainable development"; task "Create the variety of spring wheat which is tolerant to diseases, valuable in grain quality, increasing the standard by 3–4 c/ha in terms of yield; improve the elements of the technology for its cultivation".

**Field of Application**

Agriculture, providing the republic with food grain of wheat.

**Contact Information of Organization-Developer**

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**Republican Unitary Enterprise “Research and Practical Center  
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## **ASIMA SOFT WINTER WHEAT**



### **Development Description**

The variety is a mid-season. The resistance to lodging is high (8 points), plant height is 80–85 cm. The average yield in the SSIA was 69.4 c/ha, the maximum – 122.0 c/ha (Mozyr SS, 2019). The variety is characterized by high winter hardiness.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

It is highly resistant to powdery mildew, slightly susceptible to fusariosis, moderately susceptible to root rot. Weight of 1000 grains – 30.1–42.7 g. Content of raw protein – 14.8–17.5 %, gluten – 28.8–37.2 %, vitreousness – 81 %. Good baking qualities. It is entered in the State Register of Varieties of the Republic of Belarus since 2022.

**Intellectual Property Protection**

Asima soft wheat: Patent in the Republic of Belarus No 657 from 24.11.2022.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State program “High-Tech Technologies and Engineering” for 2016–2020, subprogram 1 “Innovative biotechnologies – 2020” task 8 “Create a short-stalked variety of winter wheat with high baking qualities of grain using marker-accompanying breeding methods” on the topic “Selection assessment of promising winter wheat samples for a complex of economically valuable characteristics and the creation of a food grade”.

**Field of Application**

Agriculture.

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**Republican Unitary Enterprise “Research and Practical Center  
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## **SPRING TRITICALE VARIETY DOBROYE**



### **Development Description**

The variety of spring triticale is for feed and food use. It is included in the State Register of the Russian Federation for the North-West region (2), the Central region (3), the Volga-Vyatka region (4), the Ural region (9), the East-Siberian region (11) and the Far East region (12). The variety is hexaploid. The bush is semi-erect, between-crop. The plant is of medium height. The heading stage is early medium. The weight of 1000 grains is 42.6 g. The average yield in the North-West region was 29.6 c/ha, the increase to the standard was more than 30%. The maximum yield – 82.0 c/ha was obtained in 2018 in Yaroslavl region. In the Central region the average yield was 35.0 c/ha, the increase to the standard was 10.4 %. The maximum yield – 83.3 c/ha was obtained in 2017 in Vladimir region. In the Volga-Vyatka region the average yield was 37.1 c/ha, the increase to the

standard was 7.8 %. The maximum yield – 63.7 c/ha was obtained in the Udmurt Republic in 2017. In the Ural region the average yield was 27.6 c/ha, the increase to the standard was 2.9 %. The maximum yield – 55.0 % was obtained in the Kurgan region in 2017. In the East-Siberian region the average yield was 27.0 c/ha, the increase to the standard was 22.1 %. The maximum yield – 52.4 c/ha was obtained in the Buryat Republic in 2018. In the East-Siberian region the average yield was 28.2 c/ha, the increase to the standard was 19.6 %. The maximum yield of 44.2 c/ha was obtained in the Amur region in 2017.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Under field conditions it is slightly affected by brown rust, stem rust, powdery mildew and Fusarium head blight.

**Intellectual Property Protection**

Spring Triticale Variety Dobroye. Patent of the Russian Federation No.10283 from 20.05.2019.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Agreement on the Creation of New Varieties of Spring Wheat and Triticale No. 1/13 dated 02.01.2013 with State Scientific Institution “Vladimirsky ARIPC RAAS” of Vladimir Region for 2013–2017 cooperation in the field of grain selection.

**Field of Application**

Agriculture, providing the republic with food and feed triticale grain.

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**Republican Unitary Enterprise “Institute of Plant Protection”**

**RESOILER MICROBIOLOGICAL INOCULANT**



**Development Description**

The preparation is based on microorganisms with high antagonistic and cellulolytic activity. The multifunctional action mechanism of Resoiler microbiological inoculant ensures the acceleration of plant residues decomposition (cereal straw, plant residues of other crops), reduction of the number of phytopathogenic and toxin-forming microorganisms on plant residues and in soil, and stimulation of plant growth and development. The preparation is used in cultivation technologies for field and under cover grown crops.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The preparation is applied to soil before or/and after harvesting. The application of Resoiler microbiological inoculant increases the plant productivity by 10–30 %, has a positive effect on the quality of plant products, reduces the number of phytopathogenic and toxin-forming microorganisms in soil, increases plant residues decomposition and the availability of nutritional elements for plants. There are no national analogues containing the composition of Trichoderma soil fungi-antagonists with antagonistic and cellulolytic activity. Unlike the best world analogues Resoiler microbiological inoculant can be applied before sowing and after harvesting. Resoiler microbiological inoculant is environmentally friendly, harmless to humans, animals, bees, and useful soil microorganisms, non-phytotoxic; there is no need to determine aquatic toxicity. The preparation is compatible with

fertilizers and plant protection products; it isn't accumulated in agricultural products. The technology for obtaining the preparation is an environmentally friendly microbiological process. The production and use of the preparation doesn't cause emergency situations and affect negatively on the environment.

#### Intellectual Property Protection

TR BY 600052677.010-2018, State registration number 10-0102.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program "Agricomplex – 2020", 2016–2020; subprogram "Agroindustrial complex – efficiency and quality"; task "Develop the microbial inoculant for soil rehabilitation and increase of agrobiospheres productivity".

#### Field of Application

Agricultural microbiology, plant diseases and their control.

#### Contact Information of Organization-Developer

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Republican Unitary Enterprise “Institute of Plant Protection”

## TECHNOLOGICAL REGULATIONS FOR FIGHTING AGAINST THE QUARANTINE PEST – WESTERN CORN ROOTWORM (*DIABROTICA VIRGIFERA VIRGIFERA* LECONTE)



### Development Description

The technological regulations for fighting against Western corn rootworm include a set of phytosanitary measures to localize and eliminate its outbreaks on the territory of the Republic of Belarus and the tactics of using the registered insecticides: Arkuero, SC; Vayego, SC; Mavrik, WE; Organsa, SC; Pyrinex super, EC; Euphoria, SC; Agent, WG, providing under production conditions the reduction of pests by 96.4–97.8 %, saving 5.3 c/ha of grain yield and 45.2 rubles/ha of net income.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no national analogues. It differs from foreign analogues in various parameters for monitoring of pheromones, economic thresholds of harmfulness, range of insecticides, and technical equipment. The technology has been originally developed to eliminate outbreaks and protect the corn from western corn rootworm. The technology is based on a set of phytosanitary measures and tactics for using the insecticides with different active ingredients and taking into account the number of the quarantine pest.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Scientific-Technical Program “Agricomplex – 2020”, 2016–2020; subprogram “Agroindustrial complex – efficiency and quality”; task “Substantiate and develop the system of measures for control of the quarantine pest – Western corn rootworm (*Diabrotica virgifera virgifera* LeConte) in Belarus.

**Field of Application**

Cereal crops, plant pests and their control.

**Contact Information of Organization-Developer**

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Republican Scientific Subsidiary Unitary Enterprise  
"Institute of Plant Protection"

# DATABASE ON THE DISTRIBUTION OF DOMINANT PESTS IN SORGHUM CROPS CULTIVATED IN DIFFERENT AGROCLIMATIC ZONES

A	B	C	D	E
Sorghum crop species	Broom sorghum	Sorghum-sudangrass hybrid	Sweet sorghum	Grain sorghum
Name of the pest	aphids (Aphididae family)	Thrips (Thripidae family)	—	aphids (Aphididae family)
Period of plant colonization	Leaf development (5-9 leaf stage)	Vegetation	—	Leaf development (5-9 leaf stage)
Degree of plant colonization	97.13 %	94.5 %	—	99.61 %
Harmfulness	—	—	—	—
Name of the pest	European corn borer ( <i>Ostrinia nubilalis</i> Hbn.)	Trix bonasus anaxosus (Sitobion avenae F.)	European corn borer ( <i>Ostrinia nubilalis</i> Hbn.)	European corn borer ( <i>Ostrinia nubilalis</i> Hbn.)
Period of plant colonization	leaf development (8-12 leaf stage) – stem development (10 joint stage)	Leaf development (5-9 leaf stage)	leaf development (8-12 leaf stage) – stem development (10 joint stage)	leaf development (8-12 leaf stage) – stem development (10 joint stage)
Degree of plant colonization	2.42 %	1.9 %	2.42 %	2.42 %
Harmfulness	10.0–40.0 %	—	15.0–21.0 %	10.0 %
Name of the pest	thrips (Thripidae family)	European corn borer ( <i>Ostrinia nubilalis</i> Hbn.)	—	—
Period of plant colonization	Vegetation	leaf development (8-12 leaf stage) – stem development (10 joint stage)	—	—
Degree of plant colonization	0.3 %	1.2 %	—	—
Harmfulness	—	5 %	—	—
endonym				
recedents				
subrecedents				

## Development Description

The database is drafted and presented as an MS Excel book, where the main information is entered into tables F: pests (23 species). The information blocks are structured as follows:

- there are 23 items on pests: the Russian name of the pest, the synonym in Russian, the Latin name of the pest, the synonym in Latin, crop, damaged organ, damaging stage, type of damage, economic injury level, method of recording, place of reservation (wintering), number of generations per year, average fertility (eggs/female), temperature threshold of harmfulness, temperature for leaving winter diapause, optimal temperature conditions for reproduction, optimal humidity conditions for reproduction, stage of development susceptible to protection, transformation, biological features, morphological description, photo, note;

- there are 6 items on the dominant species of pests in different agroclimatic zones of the republic (central, southern and new): sorghum species, name of the pest, period of plant infestation, degree of infestation, harmfulness, note.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are no national analogues. It differs from foreign analogues in the taxonomic structure of harmful and beneficial entomofauna of sorghum crops (grain sorghum, sugar sorghum, broom sorghum, sorghum-sudan-grass hybrid) in different agroclimatic zones of the Republic of Belarus. For the first time, the database has been developed on the spread of the main species of polyphagous, intrastem, leaf-gnawing and sucking pests in sorghum crops in the central, new and southern agroclimatic zones of the republic.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Agricultural Technologies and Food Security” for 2021–2025, subprogram “Soil Fertility and Plant Protection”, task 1.5 “Study of the composition, structure and formation of biological diversity of pests, diseases and weeds in agrocenoses for scientific substantiation of integrated systems of plant protection”, research project 1.5.5 “Study of entomofauna and harmfulness of dominant species of phytophags in sorghum”.

**Field of Application**

Protection of plants from pests, diseases and weeds and their control.

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Republican Scientific Subsidiary Unitary Enterprise  
"Institute of Land Reclamation"

## RIPPER-MOLE CULTIVATOR RMC-0.7 WITH A DEPTH LIMITER



### Development Description

RMC-0.7 soil cultivator-mole cultivator with a loosening depth limiter is designed for layer-by-layer deep loosening or deep loosening-mole cultivating with a drainer connected to a chain. The loosening depth limiter is adjusted to 70 or 60 cm.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Main technical characteristics:

- aggregation – tractors of class 2.0 (with a capacity of 130 horsepower) according to GOST 27021 ("BELARUS-1221");
- type – mounted;
- number of rippers – 1;
- drainer diameter, mm – 90;
- loosening depth, cm – up to 70;
- overall dimensions, mm:
- length – 2400;

- width – 1410;
- height – 1960;
- productivity per hour, ha – 0.9–1.2;
- weight of structure, kg – 540;
- service life, years – 8;
- climatic performance type – U1 according to GOST 15150.

Manufactured at the RUE “Institute of Land Reclamation” in accordance with the developed design documentation according to TU BY 100363825.003-2023. For use at construction sites, reconstruction and repair of melioration systems, the “Standard process map for deep loosening of reclaimed lands with tractor rippers TTK-101024243.296-2022GP” was developed by the Republican Scientific and Technical Center for Pricing in Construction. Certified in the Eurasian Economic Union (certificate of conformity No. EAEU KG417/033.BY.02.01531).

There are no domestic analogues in terms of rippers.

#### Intellectual Property Protection

None.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Contract No. 16-2021n/2021-31-315 dated September 23, 2021 for the performance of research and development (experimental design, experimental technology work) under task 2.76 “Improving technologies for the production of hydraulic engineering works and the operation of reclamation systems for their adaptation to fluctuations in heat and moisture supply and maintaining high productivity of agricultural reclaimed lands” of the subprogram “Agro-industrial complex – innovative development” of SSTP “Innovative agro-industrial and food technologies”, 2021–2025.

#### Field of Application

In agriculture to improve the water regime on reclaimed, poorly permeable mineral and peat soils with a gleyed layer with a filtration coefficient of less than 0.2/day, by converting surface water in waterlogged depressions into drainage runoff.

#### Contact Information of Organization-Developer

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**Republican Scientific Subsidiary Unitary Enterprise “Institute of Flax”**

## **FIBRE FLAX VARIETY EVEREST**



### **Development Description**

Late ripening variety of the mutant origin. It was created as a result of treating the Melina sample seeds with the chemical mutagen sodium azide ( $\text{NaN}_3$ ) at a concentration of 0.07 % with an exposure of 14 hours and subsequent repeated selection. It has blue petals.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

According to the results of the state variety testing (2019–2021), the average yield of flax retted straw is 56.1 c/ha (+ 1.3 c/ha to the average control), the maximum one is 88 c/ha obtained at the Zhirovichskaya Variety Testing Station in 2019. The average yield of flax fiber is 14.2 c/ha (+0.4 c/ha to the average control), the maximum one is 27.3 c/ha obtained at the Kobrinskaya Variety Testing Station in 2019. The average seed yield is 6.2 c/ha (+0.2 c/ha to the average control). It is resistant to lodging and highly resistant to Fusarium wilt. Since 2022 it has been included in the State Register of Agricultural Plant Varieties of the Republic of Belarus in all regions.



**Intellectual Property Protection**

Fibre flax variety Everest: patent BY 668 / Bogdan V. Z., Ivashko L. V., Bogdan T. M., Litarnaya M. A., Chultsov R. A.; applicant RUE “Flax Institute”. – No. v 2022 0039; declared 07.04.2022; published 06.01.2023 // Official bulletin / Nat. Center of Intellectual Property. – 2023. – N 1 (57). – P. 14–15.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Agrocomplex – 2020” for 2016–2020, subprogram “Agrocomplex – efficiency and quality” task 2.1 “Create flax varieties of different groups of ripeness providing flax fibre yield of 19–21 c/ha with number 12–13 and oil flax seeds yield up to 27 c/ha with oil content of 42–45 %”.

**Field of Application**

Agriculture.

**Contact Information of Organization-Developer**

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**Republican Scientific Subsidiary Unitary Enterprise “Institute of Flax”**

## **OIL FLAX VARIETY SLAVYANIN**



### **Development Description**

Created by the method of hybridization of varieties (3804 × Lirina) ×, nameless K 3687, and subsequent individual selection.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The average seed yield for the 2019–2021 testing years was 15.2 c/ha, the maximum – 30.8 c/ha was obtained at the State Agricultural Institution Zhirovichskaya Variety Testing Station in 2021. The vegetation period from germination to early yellow ripeness averaged 92 days. The 1000-grain yield is 6.1 g, lodging resistance is estimated at 4.2 points, the average plant height is 62 cm. The oil content in the seeds is 43.06 %, protein 22.50 %, the oil yield per hectare is 5.7 c, protein yield per hectare is 3.0 c. Content: oleic acid is 17.53 %, linoleic – 14.93 %, linolenic – 58.59 %. The variety is resistant to Fusarium wilt. Since 2022 it has been included in the State Register of Agricultural Plant Varieties of the Republic of Belarus in all regions. Since 2023 it has been serving as the control when testing varieties in the State Inspection for Testing and Protection of Plant Varieties.

**Intellectual Property Protection**

Oil flax variety Slavyanin: patent BY 678 / Andronik E. L., Snopov A. N., Snopova L. V., Ivanova E. V., Golub I. A., Maslinskaya M. E.; applicant RUP “Institute of flax”. – No. v20230001; application. 1/26/2023; publ. 15.06.2023 // Aficyny bull. / Nat. Center of Intellectual Property. – 2023. – N 2 (58). – P. 22–23.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Agrocomplex – 2020” for 2016–2020, subprogram “Agrocomplex – efficiency and quality”, task 2.1 “Create flax varieties of different groups of ripeness providing flax fibre yield of 19–21 c/ha with number 12–13 and oil flax seeds yield up to 27 c/ha with oil content of 42–45 %”.

**Field of Application**

Agriculture.

**Contact Information of Organization-Developer**

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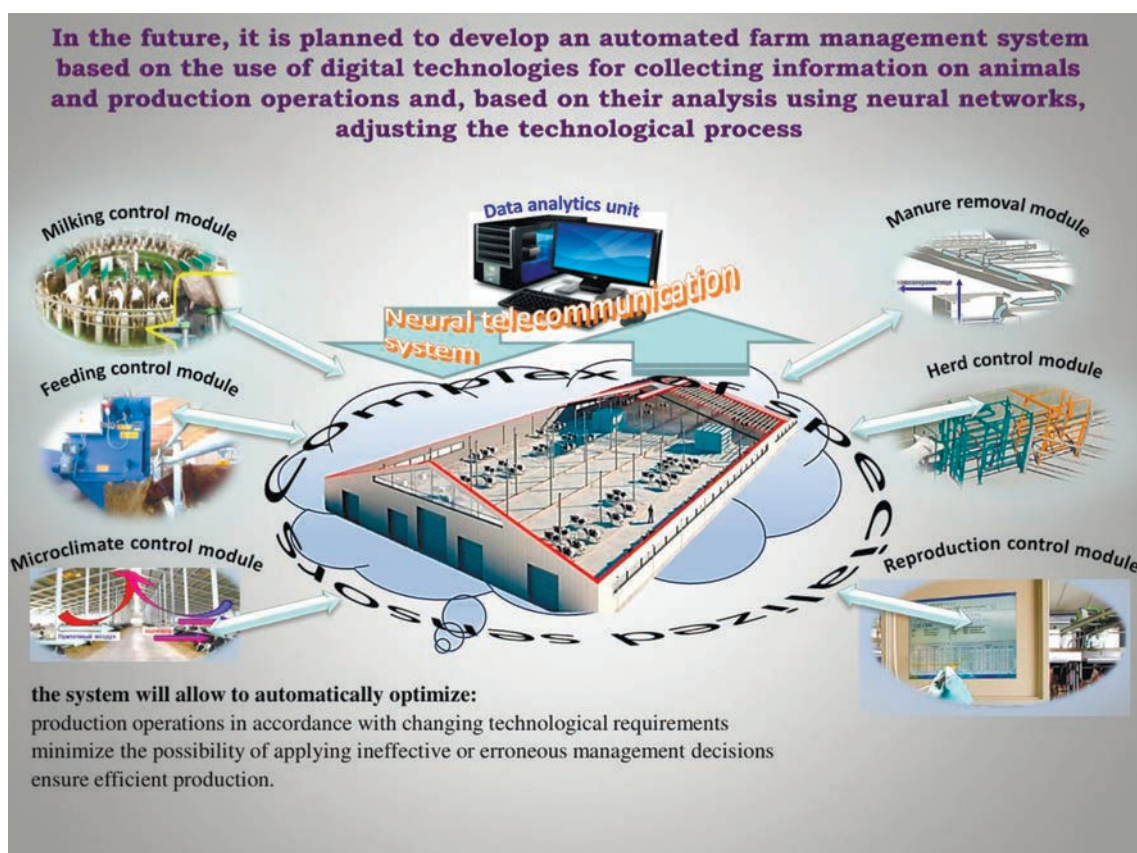
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**Republican Unitary Enterprise “Scientific and Practical Center  
of the National Academy of Sciences of Belarus for Animal Breeding”**

## SMART FARM



### Development Description

A promising direction in the creation of new generation farms (“Smart Farms”) is full automation of production processes, transformation of the biotechnical complex of the farm into a flexible self-adaptive system of machines, the parameters and modes of which are linked to the productivity of animals. The complex realizes the main principle of the fifth technological mode in the agro-industrial complex: a person serves not individual animals, but automation means. This is the basis of industrial production of livestock products, which guarantees sufficiently stable quality indicators of raw materials for processing. It is planned to develop an automated farm management system based on the use of digital technologies for collecting information on animals and production operations and, based on their analysis using neural networks, adjusting the technological processes.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The system will make it possible to automatically optimize production operations in accordance with changing technological requirements, minimize the possibility of applying inefficient or erroneous management decisions, and ensure efficient production. Corresponds the key companies.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Agricultural technologies and food security” for 2021–2025, sub-program 9.3 “Animal breeding and pedigree work”, research project 1 “Development of conceptual technological modular solutions for the creation of new generation dairy farms and algorithm of production process management based on intelligent digital technologies”, task 3.4 “Improvement of production processes and planning solutions of livestock facilities to minimize stress and increase the degree of realization of potential productivity”.

**Field of Application**

Agriculture, animal husbandry.

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Republican Unitary Enterprise "Scientific and Practical Center  
of the National Academy of Sciences of Belarus for Animal Breeding"

## INTRABREED TYPE OF PIGS "PRIPYATSKY" IN THE LANDRACE BREED



### Development Description

Through in-depth purposeful selection and breeding work based on application of advanced DNA-technologies (marker-dependent selection), an intrabreed type of pigs "Pripyatsky" in the Landrace breed with the number of 546 sows and 51 boars was created and tested. Animals of intrabreed type in the Landrace breed are superior in reproductive, fattening and meat characteristics, adapted to intensive use in pedigree and industrial pig breeding as maternal and paternal forms, ensuring the production of competitive pork with the following productivity indicators: prolificacy rate – 12.5 heads, milk yielding capacity – 65.5 kg, number of piglets and litter weight at weaning at 35 days – 11.6 heads, 91.6 kg, respectively, lean meat yield – 67 %.

The new successful breed has characteristic constitutional features that are persistently inherited, phenotypically consolidated, belongs to the meat type, characterized by an elongated lightweight body, strong bones and well defined meat forms.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The main advantage of the new competitive breeding type of pigs when compared to the Belarusian population is that animals of intrabreed type exceed the breed average by 5–9 %.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Tested intrabreed type “Pripyatsky” was created as part of task 3.23 “Develop an integrated system for the production of competitive pork based on the use of new biotechnological, genetic-population and technological methods and techniques, as well as advanced technologies for feeding pigs in order to further improve breeding and production abilities of propagated breeds of pigs” of the subprogram “Agro-industrial complex – innovative development” of SSTP “Innovative agro-industrial and food technologies”, 2021–2025; stage 3.23.1 “Create an intrabreed type of pigs in the Landrace breed, adapted to the conditions of industrial technology based on the use of modern selection and genetic techniques and methods”.

**Field of Application**

Pedigree, industrial and commercial pig breeding. Animals of intrabreed type “Pripyatsky” in the Landrace breed are used to produce high-quality pedigree young stock for replacement selection and sale to breeding farms and industrial complexes, as well as to produce parental pigs (F1) at industrial complexes.

**Contact Information of Organization-Developer:**

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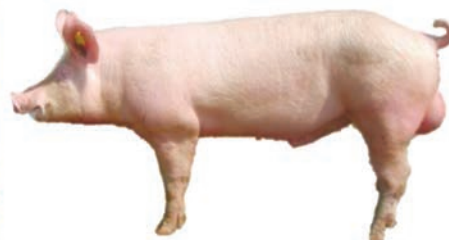
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**Republican Unitary Enterprise “Scientific and Practical Center  
of the National Academy of Sciences of Belarus for Animal Breeding”**

## **BREEDING TYPE OF PIGS OF YORKSHIRE BREED “DVINSKY”**



### **Development Description**

Pigs of Yorkshire breed “Dvinsky” with the number of 50 boars and 500 sows was created. The basic breeding enterprises are SE “ZhodinoAgro-PlemElita” of Minsk region, CJSC “Vitebskagroprodukt” of Vitebsk region. It is based on 6 lines: Dania 7723, Dixon 4988, Reichil 5507, Darak 5508, Dobry 2313, Drug 6805. The following significant target productivity indicators of the new successful breed were achieved: average sows prolificacy by type – 12.3 heads, milk yielding capacity – 62.2 kg, litter weight at weaning – 86.7 kg. Age of reaching live weight of 100 kg – 164.9 days, carcass meat yield – 64 %.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The main advantage of the new competitive breeding type of Yorkshire pigs when compared to the Belarusian population of Yorkshire breed is the superiority in reproductive, fattening and meat characteristics by 3.0–15.3 %.

### **Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Innovative agro-industrial and food technologies”, 2021–2025.  
Task 3.23.5 “Develop a program to improve breeding and production abili-

ties of Yorkshire pigs, increase their adaptive capacity under conditions of industrial pork production and create a new competitive breeding type”.

**Field of Application**

Agriculture, animal husbandry.

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**Republican Unitary Enterprise “Scientific and Practical Center  
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## **METHODOLOGY FOR CREATING EXPRESSION VECTORS OF CRISPR/CAS SYSTEM COMPONENTS AIMED AT IMPROVING THE ECONOMIC TRAITS OF FARM ANIMALS USING GENOME EDITING TECHNIQUES**



### **Development Description**

Experimental testing of methods for obtaining expression vectors of CRISPR/Cas system components aimed at animal genome editing was performed. The developed methodology allows the creation of vector constructions specifically targeted for knockout of MSTN and GGTA1 genes. This can potentially promote development of animal lines with predetermined quality characteristics.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

For the first time in the Republic of Belarus, expression vectors of CRISPR/Cas system components and methods of genome editing on its basis were developed. Corresponded to the best world analogues.

### **Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Agricultural technologies and food security”, subprogram 9.3 “Animal breeding and pedigree work” for 2021–2025, research project 5 of task 3.1 “Improvement of theoretical and methodological foundations of the selection process in animal husbandry using DNA technologies based on the identification of the spectrum of candidate genes of loci of quantitative traits that influence the formation of animal production capabilities and resistance to diseases”.

**Field of Application**

Biotechnology, genetic engineering, animal husbandry.

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**Republican Unitary Enterprise “Scientific and Practical Center  
of the National Academy of Sciences of Belarus for Animal Breeding”**

## **SYSTEM AND PERSPECTIVE MODEL OF BREEDING AND SELECTION OF RED DAIRY CATTLE IN BELARUS**



### **Development Description**

Red breed cattle have sound constitution, are resistant to diseases, characterized by high fertility and duration of economic use, average withers height is 137–145 cm, average live weight of cows is 650–700 kg, feed costs per 1 kg of milk are 0.8–0.9 feed units, average indicators: milk yield is 10,000–12,000 kg per year, bath shaped udder, udder capacity is 25–30 l, optimal hoof balance. Productivity potential is 8–10 thousand kg of milk, fat 4.0–4.8 %, protein 3.5–3.8 %, live weight of the animal is 600–650 kg.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The formed population of red Belarusian cattle has great potential opportunities as a genetic base for intrabreed improvement and interbreed crossbreeding, as it has high content of fat and protein in the milk, is characterized by unpretentiousness, resistance to metabolic stress and diseases, excellent reproductive ability, longevity. Milk of red dairy cows contains mainly beta-casein A2. A2 milk is more valuable in comparison with milk of Holstein breed animals in terms of protein content and pro-

tein quality, calcium content, which contributes to higher cheese yield due to increased concentration of kappa-casein with alleles AB, BB, while increased lactose content improves the taste of products.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Innovative agro-industrial and food technologies”, 2021–2025, subprogram “Agro-industrial complex – innovative development”, task 3.22 “Develop a program for the production of competitive livestock products based on the improvement of breeding methods for Holstein breed of dairy cattle of domestic selection, as well as red and specialized meat breeds bred in the country, optimization of methods for raising replacements, intensification of housing and feeding technology”.

**Field of Application**

Agriculture, animal husbandry.

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Republican Scientific Research Subsidiary Unitary Enterprise  
“Institute of Experimental Veterinary Medicine  
named after S. N. Vysheslesky”

## VACCINE FOR PREVENTION OF PASTEURELLOSIS, BORDETELLOSIS AND MYXOMATOSIS OF RABBITS “RESPIMIX”



### Development Description

The vaccine is intended for the prevention of pasteurellosis, bordetellosis and myxomatosis in rabbits in agricultural enterprises and farms. It is a two-component biological product consisting of a dry component – lyophilized rabbit myxoma virus, strain “KMIEV-V141”, and a liquid component – bacterial strains *Pasteurella multocida* “KMIEV-B166” and *Bordetella bronchiseptica* “KMIEV-B212” inactivated by formaldehyde and emulsified in an oil adjuvant, which serves as a solvent for the dry component. Immunity is formed 21 days after vaccination and lasts for at least 12 months.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The vaccine has no analogues in our country and abroad. It has a stimulating effect on the immune system of animals, promotes the development of specific immunity to the rabbit myxoma virus and the bacteria *Pasteurella multocida* and *Bordetella bronchiseptica*. Slaughter products and meat from vaccinated animals are sold without restrictions, regardless of the timing of vaccination.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Agroindustrial complex-2020”, 2016–2020, subprogram “Agroindustrial complex – efficiency and quality” task 3.15 “Develop innovative veterinary drugs for the diagnostics, therapy and prevention of infectious, invasive and non-infectious diseases of agricultural, fur-bearing animals and bees”, subtask 3.15.01 “Develop means of specific prevention of myxomatosis and pasteurellosis in rabbits”.

Field of Application

Veterinary medicine.

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Republican Scientific Research Subsidiary Unitary Enterprise  
“Institute of Experimental Veterinary Medicine  
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## “COLITOX-LT” INACTIVATED EMULSIFIED VACCINE FOR PREVENTION OF COLIBACTERIOSIS (ESCHERICHIOSIS) AND KLEBSIELLOSIS OF CATTLE



### Development Description

The vaccine is intended for immunization of pregnant cows, heifers and calves in livestock farms that are affected and threatened by colibacteriosis and klebsiellosis. The vaccine is made from bacterial strains of *Escherichia coli* “KMIEV-98”, *Escherichia coli* “KMIEV-B146”, *Escherichia coli* “KMIEV-39A”, *Escherichia coli* “KMIEV-B160” serotypes F41, K99 (F5), A20 (F17) and K88 (F4), respectively, the bacterial strain *Klebsiella pneumoniae* “KMIEV-B132”, the recombinant subunit B of the heat-labile toxin of *E. coli* and the oil adjuvant Montanide ISA.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

For the first time in the Republic of Belarus, a vaccine based on the recombinant protein of subunit B of the thermolabile toxin of *E. coli* was

developed and registered. Causes the production of specific antibodies against the causative agents of colibacteriosis and klebsiellosis, as well as the heat-labile toxin of *Escherichia coli* in immunized animals. Colostral immunity in young animals lasts for at least 20 days after taking colostrum. Strong immunity in cows is formed 21 days after vaccination. In calves, immunity persists for 6 months after active immunization. The slaughter of animals for meat is permitted regardless of the timing of vaccination. Slaughter products from vaccinated animals are used without restrictions. There are no analogues in the Republic of Belarus and the world.

#### Intellectual Property Protection

Patent 23624 Recombinant strain of *Escherichia coli* bacteria producing subunit B of the thermolabile *Escherichia coli* toxin: patent. BY 23624 / A. I. Zinchenko, I. S. Kazlovsky, A. V. Solovyova, O. N. Novikova, Yu. V. Lomako. – Publ. 28.02.2022.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “High-Tech Technologies and Engineering”, 2016–2020, subprogram 1 “Innovative biotechnologies-2020”, activity 1105 “Develop a vaccine manufacturing technology for the specific prevention of bacterial enteritis in cattle with heat-labile *E. coli* toxoid”.

#### Field of Application

Veterinary medicine.

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**Republican Scientific Research Subsidiary Unitary Enterprise  
“Institute of Experimental Veterinary Medicine  
named after S. N. Vysheslesky”**

## **VETERINARY DRUG “TRICLAMIZOL”**



### **Development Description**

The drug is intended for the treatment and prevention of associative helminthiasis in cattle, elk, red and sika deer, and fallow deer. The drug contains three active substances – triclabendazole, albendazole and levamisole hydrochloride.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The active ingredients of the drug, having different mechanisms, collectively exhibit a synergistic effect and prevent helminths from quickly becoming accustomed to them. The use of the drug prevents human disease from helminthiasis, common to animals and humans. Slaughter of animals is permitted 14 days after use of the drug. In case of forced slaughter of animals before the set deadline, the meat can be used as feed for carnivorous animals or for the production of meat and bone meal. There are no analogues in the Republic of Belarus and the world.

### Intellectual Property Protection

Patent No. 24136 Drug for the prevention and treatment of associative helminthiases in ruminants: patent. BY 24136 / M. V. Yakubovsky, T. Ya. Myastsova, V. M. Kaplich, O. V. Bakhur. – Publ. 30.12.2023.

### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Industrial bio- and nanotechnologies-2020”, 2016–2020, task 4-20 “Develop a complex broad-spectrum drug for early therapy and prevention of trematodes and associated nematodes in cattle”.

### Field of Application

Veterinary medicine, agriculture.

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**Republican Subsidiary Unitary Enterprise “Institute of Fisheries”**

## **TECHNOLOGY OF APPLICATION OF MICROBIAL PREPARATION OF COMPLEX ACTION IN FISH PONDS IN ORDER TO INCREASE CONCENTRATION OF BIOGENIC ELEMENTS DURING CULTIVATION OF CYPRINOID FISH**



### **Development Description**

Technological instruction for the use of a microbial preparation of complex action in fish ponds, the imicrobial preparation Bioprud, has been developed. The technology of rehabilitation and enrichment of fish ponds with biogenic elements by using the microbial preparation of complex action “Bioprood” with antimicrobial, hydrolytic, phosphate-mobilizing and nitrogen-fixing activities is used to transform biogenic elements from soils into aquatic environments, improve the quality of fish habitat, reduce morbidity, increase productivity of outgrowth and feeding ponds. The used microbial preparation “Bioprood” is not toxic for humans, animals and plants, has a prolonged effect. The co-executive organization is SRPA “Chemical Synthesis and Biotechnology”.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Existing analogues of regeneration of biogenic elements from soils into water mainly relate to the impact of chemical preparations on soils: lime and sylvinite, as well as the removal of ponds in summer. The use of bacterial preparations on soils was carried out for the first time.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Program “Science-intensive technologies and technology” for 2021–2025, subprogram 1 “Innovative biotechnologies”, task 64 (71) “Develop and implement a technology for improving and enriching fish ponds with biogenic elements based on biotransformation of bottom sediments with a microbial preparation of complex action”.

**Field of Application**

Agro-industrial complex (fish farming).

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**Republican Subsidiary Unitary Enterprise “Institute of Fisheries”**

**TECHNOLOGY OF GROWING WHITE AMUR PLANTING  
MATERIAL PROVIDING IMPROVEMENT OF PRODUCTION  
INDICATORS**



**Development Description**

Technology (technological regulations for growing white amur seedlings that improve production indicators) includes fish-breeding and biological norms ensuring increase of production indicators of white amur seedlings (fingerlings and yearlings), including the preparation of outgrowth ponds for growing white amur seedlings, transportation of the larva, growing of the larva in workshop conditions, stocking of ponds, formation and stimulation of the development of the natural food base of young white amur in ponds, feeding with concentrated feed, monitoring the state of the ecosystem and the growth of fish, prevention and treatment of fish diseases, fishing of ponds, wintering of amur fingerlings, further cultivation of the obtained planting material.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The developed technology provides a total fish productivity of up to 400 kg/ha, including up to 400 kg/ha for white amur, survival rate (from the spent 3-day larva) of 40 % or more, compared with the traditionally used technology “Growing annual herbivorous fish without planting other species” (clause 10 of the TR “Fish and biological standards for the operation of pond and gardenfarms of Belarus”): total fish productivity – 250–300 kg/ha, including 100–120 kg/ha for white amur, survival rate (from the spent 3-day larva) – 20–25 %. It also provides an increase in survival rate from 75 % to 80–85 % (with a planting density of up to 500 thousand pcs/ha) of the received planting material during wintering and during the spring stocking of ponds with the white amur yearlings due to the increase in fish preparation for wintering. In relation to the best world samples, the technology has no analogues within 2–3 fish-breeding zones.

**Intellectual Property Protection**

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SSTP “Innovative agro-industrial and food technologies” for 2021–2025, subprogram “Agropromcomplex – innovative development”, task 3.26 “Develop a scientifically based technology for growing white amur seedlings, providing improved production indicators”.

**Field of Application**

Technology is intended for use at pond aquaculture enterprises of 2–3 fish-breeding zones.

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**Republican Subsidiary Unitary Enterprise “Institute of Fisheries”**

## **FISH HYDROLYZATE FROM FRESHWATER FISH PROCESSING WASTE**



Liquid hydrolysate

Dry hydrolysate

### **Development Description**

The fish hydrolyzate is a homogeneous fine powder from light beige to dark brown in color, highly soluble in water obtained as a result of enzymatic hydrolysis of fish waste.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The production technology does not contain alkalis, acids, and various salts (100 % natural feed concentrate). The crude protein content in dry fish hydrolyzate is 45–50 %, in liquid hydrolyzate is 3–4 %. Depending on the hydrolyzate production technology, the crude fat content does not exceed 9 % and crude ash is up to 10 %.

Intellectual Property Protection

Patent of the Republic of Belarus No. 23478.TR BY 100035627.0232019.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

State Research Program “Quality and efficiency of agro-industrial production”, 2016–2020; task 7.18 “Obtaining and studying the composition and properties of fish hydrolyzate for use in aquaculture”.

Field of Application

Agro-industrial complex (fish farming).

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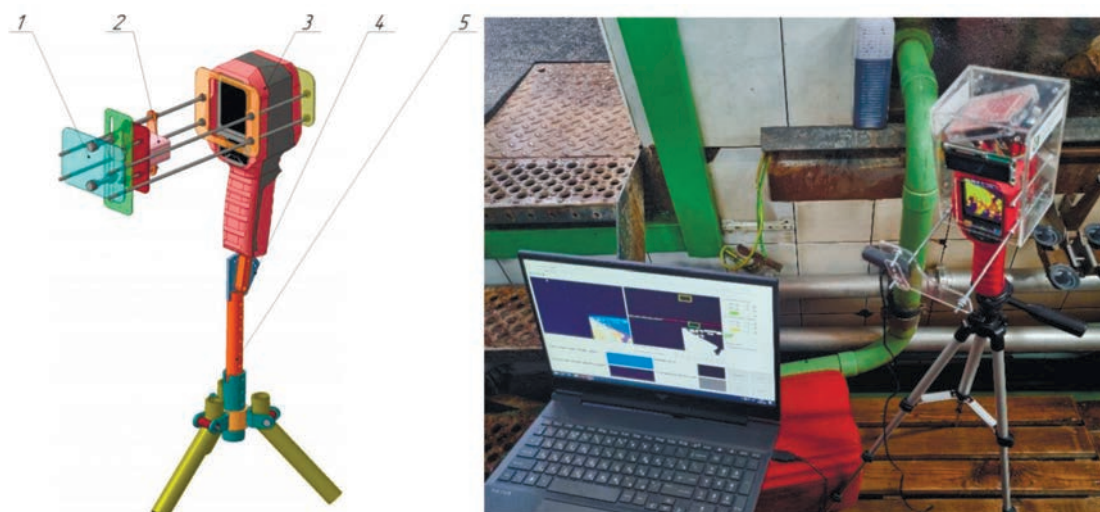
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**Republican Unitary Enterprise**  
“Scientific-Practical Center of the National Academy of Sciences of Belarus  
on Agricultural Mechanization”

## DEVICE FOR BIOMETRIC IDENTIFICATION OF THE PREMASTITIC CONDITION OF THE UDDER OF DAIRY HERDS CATTLE



1 – mounting bracket (on which temperature, light, and distance sensors are mounted); 2 – videocamera;  
3 – thermal imager; 4 – regulator tilt angle of the thermal imager; 5 – tripod

### Development Description

A device for biometric identification of the pre-mastitis state of the udder of a dairy cattle herd is designed to obtain a stream of images of the udder and remote measurement of the temperature in its lobes for the timely diagnosis of mammary gland diseases. The use of this device allows you to: clarify the localization of pathological changes; determine the intensity of the pathological process; determine the prevalence and nature of temperature changes; monitor the dynamics of the mammary gland condition. The processing of graphical data is carried out using independently developed software Cows Recognizer.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Determines the subclinical form of mastitis at an early stage, which will allow timely therapeutic and preventive actions to be taken, which in turn

will lead to a reduction in labor costs and an increase in milk production in view of maintaining the productive longevity of the dairy herd at a high level. The device for biometric identification of the predisposition state of the udder of a dairy cattle herd in integration with cattle herd management systems has no analogues.

#### Intellectual Property Protection

Device for biometric identification of the pre-mastitis state of the udder of a dairy herd: patent 5082 Rep. Belarus, ICID (13) 15 – 03 / E. L. Zhilich, A. A. Zheshko, Yu. N. Rogalskaya, V. V. Nikonchuk, S. A. Tsalko, O. L. Ekelchik; applicant RUE “Scientific and Practical Center of the National Academy of Sciences of Belarus for Agricultural Mechanization”. – No. f 20220151; application 12/12/2022; publ. 06/30/2023 // Official bulletin / Intellectual Property Center. – 2023. – № 3. – P. 114.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

SRP “Agricultural Technologies and Food Security”, 2021–2025, subprogram “Mechanization of Agricultural Processes and Precision Agriculture”, task 6.1 “Reducing resource and energy consumption in milk production”, project 2 “Development of a method and device for biometric identification of the pre-mastitis state of the udder of dairy cattle”.

#### Field of Application

On dairy farms and complexes.

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**Republican Unitary Enterprise “Scientific and Practical Center  
of the National Academy of Sciences of Belarus on Foodstuffs”**

## **SPECIALIZED FOOD PRODUCTS WITH REDUCED PHENYLALANINE CONTENT**



### **Development Description**

Recipe formulations of low-protein foods for children with phenylalanine hydroxylase deficiency have been developed:

- low-protein baking mixes are mixtures of pre-prepared ingredients;
- low-protein pasta products;
- low-protein dry potato products (low-protein dry potato mashed potatoes, – low-protein potato dumplings);
- food concentrate. Low-protein dry porridges;
- granulated food concentrate. Low-protein cereals.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The study of the effectiveness of low-protein potato dumplings and mashed potato low-protein domestic production in comparison with the best foreign analogues based on the study of postprandial glucose response showed no significant differences in the rise in glucose levels in adult volunteers. This applies to the comparative analysis when consu-

ming both low-protein potato dumplings and low-protein mashed potato. The obtained results indicate that the developed products are not inferior in quality to foreign analogues and can be used for nutrition of patients with phenylketonuria.

#### Intellectual Property Protection

The National Intellectual Property Center has obtained a patent for the invention “Composition for the production of pasta with a reduced protein and phenylalanine content and a method of their production”, patent No. 23819 dated July 27, 2022.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

Industrial Scientific-Technical Program “Baby Food. Quality and Safety”, 2016–2020; task 12 “Develop social specialized food products with reduced phenylalanine content”.

#### Field of Application

Cereal production, production of pasta products, production of canned food and concentrates for children and dietary food.

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**Republican Unitary Enterprise “Scientific and Practical Center  
of the National Academy of Sciences of Belarus on Foodstuffs”**

## **DIFFUSION JUICE TREATMENT TECHNOLOGY USING ELECTRO-MEMBRANE PROCESSING**



Developed technological scheme of diffusion juice purification

### **Development Description**

Electrodialysis purification of diffusion juice using ionite membranes is a progressive and at the same time little-researched method which increases sugar output using electrochemical treatment. This uses the cheapest type of energy – electricity.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Juice treatment according to the proposed technological scheme allows increasing sugar yield by 1.05 % to beet weight, reducing the color of juice by 19.3–28.4 %, and reducing the consumption of limestone for juice purification by 0.7 % of the beet weight, excluding from the scheme of purification of diffusion juice II saturation, additional defecation and sulfitation, reducing the yield of conventional molasses by 2.7–3.1 % to the mass of beets and the sugar content in it by 1.2–1.4 % to the mass of beets.

The efficiency of diffusion juice treatment using electromembrane processing was experimentally confirmed during production tests of the pro-



cess at Gorodeysky Sugar Plant OJSC. The use of the technology allows increasing the purity of purified juice by 4–5 %, reduce the content of calcium salts by 76.5–93.5 %, as well as remove more than 90 % of the main molasses.

#### Intellectual Property Protection

Method of diffusion juice treatment: Pat. 23796 Rep. of Belarus, МПКС 13 B 20/06, C 13 B 20/18. O. K. Nikulina, O. V. Dymar, O. V. Koloskova, M. R. Yakovleva; applicant – Scientific and Practical Center of the National Academy of Sciences of Belarus for Foodstuffs – N A20200163; declared. 10.06.2020; publ. 30.08.2022 // Official Bull. / National Center for Intellectual Property. – 2022. – № 4 (147). – P. 50.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

ISTP “Food Technologies” for 2019–2020, task 4 “Improve the technology for producing white sugar using electrodialysis for the demineralization of sugar intermediates”.

#### Field of Application

Sugar industry.

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**Scientific and Production Republican Subsidiary Unitary Enterprise  
“Institute of Meat and Dairy Industry”**

## **LINE OF FUNCTIONAL SPECIALTY MEAT-BASED FOOD PRODUCTS WITH REDUCED PHENYLALANINE CONTENT**



### **Development Description**

The line of functional specialized meat-based food products with a reduced content of phenylalanine includes:

- canned vegetable and meat products with a reduced content of phenylalanine (hereinafter referred to as “canned food”). Canned food contains no more than 2 g of protein (150 mg of phenylalanine) per 100 g, which meets the requirements for food products with a reduced content of phenylalanine in accordance with TR CU 027/2012 “On the safety of certain types of specialized food products, including dietary therapeutic and dietary preventive nutrition”. When conducting preclinical tests at State Scientific Institution “Institute of Physiology of the National Academy of Sciences of Belarus” the level of phenylalanine in the blood of rats receiving vegetable meat cans with a reduced content of phenylalanine for 3, 7 and 14 days practically did not change compared to the control group, while it increased by 3–3.5 times in rats fed by canned meat (the level of phenylalanine did not decrease);

- boiled vegetable and meat sausage products with a reduced content of phenylalanine for dietary preventive nutrition. Sausages contain no more than 2.0 g of protein, 150 mg of phenylalanine and are intended for feeding people who limit protein intake (including children over 1.5 years old), and can also be used in feeding other categories of the population. It should be noted that canned food and sausages with a reduced content of phenylalanine contain only natural ingredients: pork, beef, butter, carrots, potatoes, onions, rice. The production of canned food and sausages with a reduced content of phenylalanine is carried out at Orsha Meat Canning Plant OJSC.

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

There are only natural ingredients in the composition (pork, beef, butter, carrots, potatoes, onions, rice), the appearance of sausages is identical to traditional ones, lower cost.

#### **Intellectual Property Protection**

A line of functional specialized meat-based food products with a reduced content of phenylalanine. Patent of the Republic of Belarus No. 23545.

#### **Name of the programme, subprogramme, project, business contracts under which the development was obtained**

As part of the implementation of the Republican Scientific-Technical Program “Baby Nutrition”, 2011–2015 specialists from Republican Unitary Enterprise “Institute of Meat and Dairy Industry” have developed a range of canned vegetable and meat products with a reduced content of phenylalanine: “Vegetable puree with pork”, “Mashed potatoes with potatoes and pork”, “Vegetable puree with beef”, and “Mashed potato and beef”. In cooperation with the Belarusian Republican Public Association for Helping Children with Phenylketonuria “Future without Borders” a range of boiled vegetable-meat sausage products with a reduced content of phenylalanine for dietary preventive nutrition has been developed at our own expense: sausages “Solnyshko”, “Smile”, and “Fairy Tale”.

#### **Field of Application**

Food industry.

#### **Contact Information of Organization-Developer**

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**Scientific and Production Republican Subsidiary Unitary Enterprise  
“Institute of Meat and Dairy Industry”**

**TECHNOLOGIES FOR PRODUCTION  
OF DRY AND FROZEN CONCENTRATED STARTERS  
FOR THE PRODUCTION OF DAIRY PRODUCTS BASED  
ON DOMESTIC START CULTURES  
FROM THE REPUBLICAN COLLECTION  
OF INDUSTRIAL STRAINS OF STARTER CULTURES  
AND THEIR BACTERIOPHAGES**



**Development Description**

The scientific research carried out in the field of biotechnology belongs to the V technological structure and is aimed at the further development and improvement of dry and frozen concentrated starter cultures for the milk processing industry. In 2023, 26 types of frozen and 19 types of dry starter cultures were produced for the dairy industry (for cottage cheese, sour cream, cheeses, yogurt, fermented dairy products with probiotic cultures, etc.), 5 types of starter cultures for the population. In 2023, the production of starter cultures of dry concentrated monovid propionic acid bacteria was carried out for the manufacture of cheeses with high and medium second heating temperatures to form a pattern, as well as new types of concentrat-

ed frozen polyvid starter cultures based on thermophilic *Lactobacillus Lactobacillus delbrueckii* subsp. *Lactis* for the production of semi-hard cheeses (CHEESE-13, CHEESE-14, CHEESE-15, CHEESE-16) and for use as additional cultures in the production of cheeses (Betabalance line).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Specially selected consortia of cultures of lactic acid microorganisms from the Republican Collection of Industrial Strains of Starter Cultures and their bacteriophages being a national treasure are used for the production of dry and frozen concentrated starter cultures (Resolution of the Council of Ministers of the Republic of Belarus N 1043 dated December 19, 2016). High-tech technologies developed in the Republic of Belarus are used in the process. According to their characteristics, the starter cultures are similar to their foreign analogues.

#### Intellectual Property Protection

The intellectual property is protected as a know-how.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

The developments have been carried out over the past 7 years within the framework of individual BRFFR projects and the following programs:

- State Program “High-Tech Technologies and Engineering”, 2016–2020; subprogram 1 “Innovative biotechnologies”;
- State Scientific-Technical Program “Agro-industrial complex 2020”, 2016–2020; subprogram “Agro-industrial complex - efficiency and quality”;
- State Research Program “Quality and efficiency of agro-industrial production”, 2016–2020; subprogram “Food Security”;
- State Research Program “Agricultural Technologies and food safety”, 2021–2025, subprogram “Food safety”;
- State Program “High-Tech Technologies and Engineering” for 2021–2025, subprogram “Innovative biotechnologies”.

#### Field of Application

Food industry.

#### Contact Information of Organization-Developer

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Scientific and Production Republican Subsidiary Unitary Enterprise  
“Institute of Meat and Dairy Industry”

## DRY DAIRY PRODUCT WITH A REDUCED PROTEIN CONTENT



### Development Description

The technology for the production of a dry milk product with a reduced protein content has been developed. The product is intended for nutrition of various groups of the population over the age of three, who are forced to limit themselves in protein consumption and follow low-protein diet therapy, as well as for nutrition of people with impaired protein metabolism. The reduced dairy product contains up to 1 g of protein and less than 50 mg of phenylalanine per 100 g of ready-to-use product. The control of an essential amino acid allows these products to be used in the diet of people suffering from the phenylketonuria disease (a disorder of the metabolism of phenylalanine (amino acid) in the body).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

The product has a natural milk composition, it does not contain artificial flavors, dyes, milk fat substitutes and vegetable oils. The reduced protein content is achieved by rational selection of the components, which consists in fractionation of dairy raw materials and composition balanced in terms

of nutritional and energy value. RUE “Institute for Meat and Dairy Industry” carries out industrial production of dry milk product with a reduced protein content in its own production, being the only manufacturer of low-protein dairy products in the Republic of Belarus.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

ISTP “Baby food. Quality and safety” for 2016–2020, task 12.2 “Develop technology and master the production of dry dairy products with a reduced protein content intended for the preparation of dairy products for baby food”.

Field of Application

Food industry.

Contact Information of Organization-Developer

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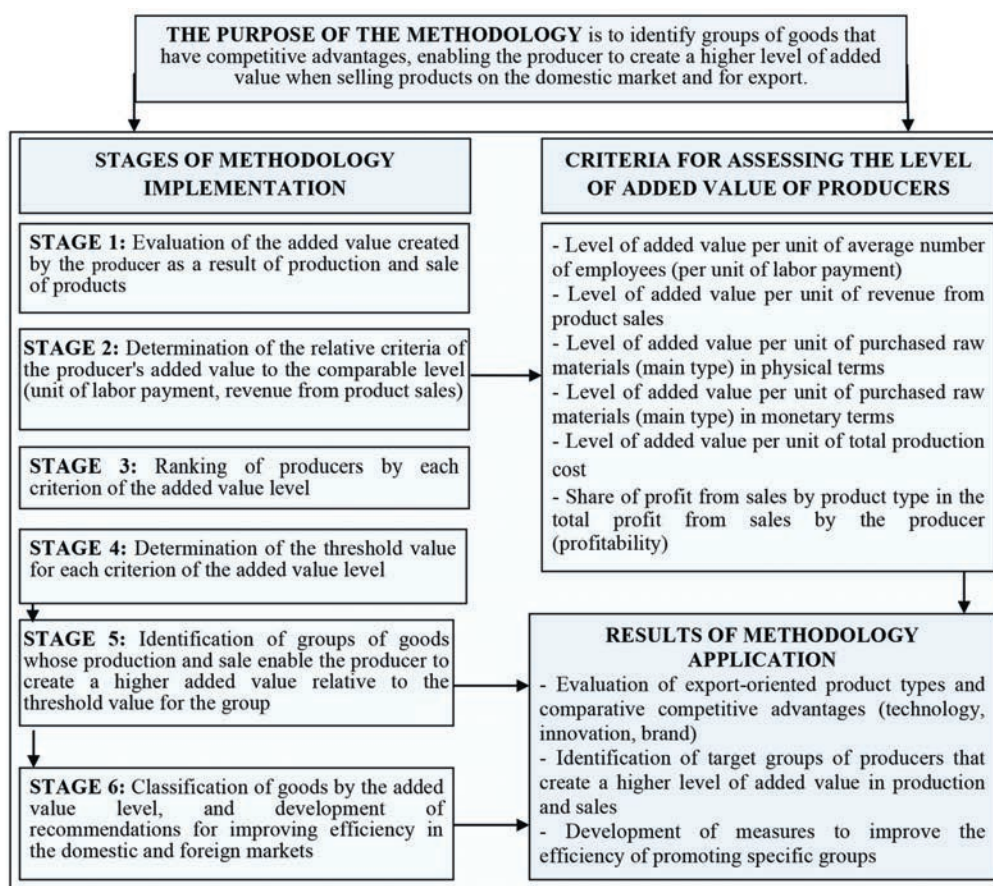
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**Republican Scientific Unitary Enterprise**  
 “Institute of System researches in the Agro-Industrial Complex  
 of the National Academy of Sciences of Belarus”

## METHODICAL RECOMMENDATIONS FOR DETERMINING THE CRITERIA FOR CLASSIFYING FOOD PRODUCTS AND AGRICULTURAL RAW MATERIALS AS HIGH VALUE-ADDED GOODS



Methodology for Identifying and Classifying Food Products that Ensure the Formation of Higher Added Value at the Level of Enterprises and Types of Economic Activities

### Development Description

The methodological recommendations are designed to identify products with a high level of added value (hereinafter – AV) in relation to specific producers, using particular indicators of competitive advantages (such as the level of AV per unit of average number of employees; revenue from product sales; purchased raw materials; total cost of sold products; and profit margin by product type). They also involve calculating threshold AV indicators

by type of economic activity to subsequently identify and analyze groups of producers that generate the majority of AV.

The recommendations provide the necessary informational and methodological tools for identifying effective practices to increase revenue and AV for agro-industrial enterprises by highlighting and maximizing their competitive advantages. They allow for a reasoned development of current strategies for promoting domestic agro-food products in both domestic and international markets, considering specific costs (labor payment, costs of fixed and circulating assets, and expenses on R&D and innovation).

Implementing this development into the management practices of the agro-industrial complex at the national and regional levels will contribute to achieving the target criteria set out in the Doctrine of National Food Security of the Republic of Belarus until 2030 (Resolution of the Council of Ministers of the Republic of Belarus dated December 15, 2017, No. 962).

**Technical advantages. Scientific and technical level (in relation to the best national and foreign analogues)**

Corresponds to the fourth technological order.

Intellectual Property Protection

None.

**Name of the programme, subprogramme, project, business contracts under which the development was obtained**

The research project titled “Develop Methodological Recommendations for Determining the Criteria for Classifying Food Products and Agricultural Raw Materials as High Added Value Goods” was executed under contract № 24/2021-31-351 dated November 26, 2021, with the National Academy of Sciences of Belarus.

Field of Application

Agro-industrial complex. Can be used for economic analysis at the level of organizations and types of economic activities, providing an objective basis for developing effective measures to increase revenue and AV of producers by identifying, assessing, and maximizing competitive advantages of products in domestic and export markets.

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## TABLE OF CONTENTS

### DEPARTMENT OF PHYSICS, MATHEMATICS, AND INFORMATICS

6	Hardware and Software Complex of Laser-Optical Scanning for Automated Ballistic Identification System
8	Optoelectronic Oscillator
10	Air Plasma Jet Generator
12	Laser Therapeutic Apparatus "Promethey"
14	Phototherapy Apparatus for Treatment of Hyperbilirubinemia of Newborns
16	Near-field Optical Microscope Based on Evanescent Quasinondiffraction Light Beams
18	Autonomous NaI(Tl) Gamma-Ray Spectrometer for in Situ Underwater Measurements
20	Laser-Optical Defect Analyzer
22	IFL-E15-PC Laser Emitter
24	IFL-E25-PC Laser Emitter
26	IFL-E85-PT Laser Emitter
28	IFL-N180A Laser Emitter
30	National Etalon for Devices of Spectral Brightness, Spectral Radiance and Radiation Intensity in the Wavelength Range from 0.2 to 3.0 micrometres
32	National Etalon for Polarization Mode Dispersion Device in Optical Fiber
34	Optical Coherent Tomography Device
36	Completely Solid-State Multiwave Diode-Pumped Laser System
38	Portable Photoacoustic Methane Detector
40	Scanning Multi-Wavelength Polarization Raman Lidar for Atmosphere Aerosol and Clouds Probing
42	Device for Control of Temperature Fields of Microwave MIC with Laser Raman Spectroscopy Method
44	Device for Monitoring the Wavefront Shape and Spatial Characteristics of Solid-State and Injection Lasers Radiation
46	Device for Molecular-Beam Epitaxy of Nitrides
48	Photostimulators for Hydrobionts
50	Fluorescent Analyzer of Ultra-Low Concentrations of Biological Molecules with Fluorescent Labels Based on Quantum Dots and Nanoplates Using Two-Photon Laser Excitation
52	Software and Hardware Complex for Forensic Purposes Based on a Digital Camera for Determining the Dimensional Parameters of Objects
54	Highly Effective Led Luminaires for Greenhouse Horticulture Lighting
56	BelAI.by Artificial Intelligence Platform
58	Software Package "Software Package for Unified Automated Information System for Accounting of Persons Vaccinated Against COVID 19"
60	Computer Simulation of Potential Medicinal Products
62	Automated Information System for Identification, Registration, Traceability of Animals and Products of Animal Origin (AITS) Integrated With the Russian State Information System for Electronic Veterinary Certification "MERCURY"
65	Multi-Level Belarusian Space System for Earth Remote Sensing (MBSSERS)

- 68 Distributed System for Acquiring, Processing and Disseminating Operational Space Data from Spacecraft (“AQUA”, “SUOMI NPP”, “NOAA 20”, “MetOp”, “Fengyun-3”)
- 70 Strain Sensor
- 72 Thermoelectric Radiation Receiver

#### DEPARTMENT OF PHYSICAL AND TECHNICAL SCIENCES

- 74 Novel Method of Producing Graphene-Like Materials
- 76 Highly Efficient Electromagnetic Protection Systems for On-board Instruments of Rocket and Space Vehicles with Improved Operational Characteristics
- 78 Fluoroplastic Composite Material Superfluvis+
- 80 Flexible Polymer Tubes for Pneumosystems
- 82 Pads of Rail Fasteners for High-Speed Railway Lines and Heavy Traffic
- 84 Ultra-Impact-Resistant Composite Materials “Etamide” Based on Blends of Polyamide 6 with Specially Functionalized Polymers and Copolymers of Polyolefins for Flexible Pipes, Hoses and Blow Products
- 86 Low-Noise NAO friction Materials for Friction Units of Transport and Technological Machines
- 88 Equipment Set for Control of Friction Stir Welding
- 90 Equipment Set for Control of the Depth of Strengthened Layers
- 92 Magnetic Measuring Unit
- 94 Layered Structure Material with High Magnetoelectric Properties
- 96 Wear-Resistant Chromium Iron for Casting Consumable Parts of Centrifugal Crushing and Grinding Equipment
- 98 Establishment of Production for High-Quality Cutting Tools Under the “BYTC” Brand (Belarusian Hardened Carbide)
- 100 Superconducting Half-Wave Resonators Made of Extremely Pure Niobium
- 102 Submillimeter-Thick Vapor Chamber With Powder Capillary Structure
- 104 Prefabricated Mirror Substrate Made of Silicon Carbide
- 106 Antigravity Heat Pipe (AGHP)
- 108 Complex of Equipment for Recycling Organic Waste Using Received Thermal Energy
- 110 Methods, Techniques, and Algorithms for Technical Implementation of Radar Detection and Tracking of Hypersonic Aircraft Vehicles
- 112 System of Non-Cooperative Radar Recognition of Aircraft Types for On-board Pulse-Doppler Radar
- 114 Unmanned Aerial System “Burevestnik”
- 116 Dynamic Three-Axis Bench for Testing UAV Modules
- 118 Multifunctional Small-Sized Gyro-Stabilized Video System in the Visible and Infrared Wavelength Ranges with the Function of Automatic Tracking of Ground Objects
- 120 High Efficient Water Supply System
- 122 Airless Wheel
- 124 Cranio-Caudal Hypergravity Therapy Unit
- 126 Centrifugal-Impact Crushers DC with Integrated Dedusting System
- 128 Technological Plants for Obtaining Mineral Powders
- 131 Silicon Carbide Ceramic Mirrors for Space Optical Systems
- 134 Multifunctional Scanning Probe Microscope
- 136 Technologies and Equipment for Magnetorheological Treatment of Precision Components

- 138 Pyrometer PIF 18
- 140 Technological Principles of Developing the Components of the Meteoroid Shielding of Higher Durability for Space Vehicles
- 142 Vapor Chamber and Heat Pipe Cooling Systems
- 144 60 kW Plasma Torch (Plasma Generator)
- 146 Oimol CL Bio Biodegradable Grease
- 148 Equipment and Technology for Restoration – Strengthening of Quick-Wearing Parts of Machines and Structural Elements Using Hypersonic Metallization Method
- 150 Electro-Hydraulic Control System of Plowing Unit Working Bodies
- 152 On-Board System for Monitoring the Technical Condition of Gearboxes of Belaz Mining Dump Truck
- 154 Unit for Laser Micro-Processing of Microelectronic Materials
- 156 Diamond-Containing Metal-Matrix Composite for Magnetic-Abrasive Treatment

#### DEPARTMENT OF CHEMISTRY AND EARTH SCIENCES

- 158 Engineering of Integrated Technology for Processing of Potassium and Polymineral Potassium Ores
- 160 Plant Growth Regulator
- 162 Enzyme Immunoassay Kit for the Determination of Recombinant Human Lactoferrin in the Milk Of Goats-Producers, and Food and Pharmaceutical Products Prodoscreen<sup>®</sup> ELISA-rhLF
- 164 Universal Antioxidant Potential Indicator for Diagnostics of Human Sustainability to Oxidative Stress
- 166 Enzymatic Synthesis of Liponucleotids and Determination of Their Resistance to Pancreatic Phospholipase A<sub>2</sub> Action (Lipolysis)
- 168 “PLA<sub>2</sub>-PDA” Assay Kit for Pancreatitis Detection
- 170 Complex of Three Enzyme Immunoassay Systems for Determination of Antibiotics in Foodstuffs
- 172 Complex of Six Enzyme Immunoassay Kits for Determination of Mycotoxins in Food and Feed
- 174 Lipid-Dependent Regulation of the Activity of Secretory Phospholipases in Microorganisms as a New Strategy for Increasing the Effectiveness of Antimicrobial Drugs
- 176 Epibrassinolide Biopreparation Technology Using Green Chemistry Strategy
- 178 New Processes for Catalytic Processing of Hydrocarbons Turpeness
- 180 Antibacterial Polysaccharide-Silver Nanocomposites

#### DEPARTMENT OF BIOLOGICAL SCIENCES

- 183 Biotechnological Collection of Cell Cultures
- 184 Cell Technologies for Medicine
- 187 Innovative Biomedical Cell Product for the Treatment of Alopecia
- 188 Innovative Biomedical Cell Product with Increased Restorative Capacity
- 190 Innovative Biomedical Cell Product with Enhanced Immunosuppressive and Anti-Inflammatory Properties for Use in Otorhinolaryngology
- 192 Innovative Biomedical Cell Product for the Treatment Patients With Acquired Hypoparathyroidism



194	Innovative Biomedical Cell Product for Cell Therapy of the Degenerative Diseases of the Retina
196	Innovative Biomedical Cell Product for the Use in Cell Therapy of Diseases of the Female Reproductive System
198	Biomedical Cell Products
200	Innovative Biomedical Cell Product for the Treatment of Type 1 Diabetes Mellitus
202	Innovative Biomedical Cell Product for the Treatment of Systemic Sclerosis
204	Innovative Biomedical Cell Product for the Treatment of Oncological Diseases (Kidney Cancer, Bladder Cancer)
206	Scientific Object "Zoological Collection and Genetic Bank of Wild Fauna"
208	Scientific Support of Red Deer Settlement in Hunting Farms of Belarus
210	Scientific Support for Preservation of Bison in Belarus
212	Axonomic Composition and Genetic Diversity of East Antarctic Biota
214	Test System for Express-Diagnostics of Forest Woody Plants Mixed Infections
216	Modified Ion-Exchange Immunomodulating Substrate
218	Natural Ecosystems Remote Monitoring Technologies
220	Variety of White Greek Lupine "Ellin"
222	Microbial Preparation "Bioprud"
224	Bioproductin Microbial Preparation
226	Multiphage-C Biopreparation
228	Set of Specific Hybridization Probes for Determining Changes in the Lysosomal-Associated Protein-2 (Lamp2) Gene in Humans by the MLPA Method for Danon Disease Diagnosis
230	Method for the Cattle Leukemia Diagnosis
232	Method for Detecting a Genetic Predisposition to Joint Inflammation in Children
234	DNA Identification and Identification of Varieties of Berry Crops
236	DNA Identification and Identification of Varieties of Fruit Crops
238	Microbial Preparation BioKit
240	Annexin-PNPase Chimeric Protein Produced by Recombinant Strain of Bacteria <i>Escherichia coli</i>
242	Bilametritis Probiotic Preparation
244	Phlebiopin Biopreparation
246	Cell-Free Synthesis of Protein with Intensive Sweet Taste – Brazzein

#### DEPARTMENT OF MEDICAL SCIENCES

249	Neuroprotective Properties of <i>Bifidobacterium Longum</i> in the Temporal Lobe Epilepsy Model
250	Human Epidermal Growth Factor with Amino Acid Substitution D46G
252	Technology of Perineural Stem Cell Migration
254	Experimental Rationale for Methods of Regulating Cellular Uptake and Cytotoxicity of Fluorescent Quantum Dots and Their Conjugates with Antitumor Compounds From the Group of Pentacyclic Triterpenoids
256	Method of Preparation of a Standard Sample of Cyclic Caprolactam Dimer and its Determination
258	Microbiological Method of Reducing Radionuclide Bioavailability in Soils
260	<sup>137</sup> Cs Soil-To-Plant Transfer Model for the Remote Radioecological Consequences Following Technogenic Emissions



- 262 RISKAgro – Electronic Interactive Handbook for the Contamination Risk Assessment of Radionuclides for Agricultural Products above the Established Food Safety Standards
- 264 Information Database “Levels of Radioactive Contamination of the Main Forest-Species Wood, Soil and Forest Litter in High-Level Contaminated Territories”
- 266 Heterogeneity of Nanomechanical Properties of Cells
- 268 Cytotoxic and Photosensitizing Extracts of Lichens in Relation to Cultures of Human Tumor Cell
- 270 Reproductive System as a Damaging-Action Marker of RF Electromagnetic Radiation. Development of Protection and Correction Methods

#### DEPARTMENT OF HUMANITIES AND ARTS

- 274 Methodology for Identifying the Structure of Population Groups Allocated in Relation to the Belarusian NPP (Supporters, Opponents, Difficult) and Predicting Their Behavioral Practices in the Future
- 276 Methodological Strategy for Identifying Information Events-Triggers
- 278 Belarusian Ethnophilosophy in the System of National Culture
- 280 Organizational and Legal Instruments for Commercialization of the Results of Scientific and Technical Activities
- 282 Macroeconomic Instruments in the Belarusian Institutional Model
- 284 “Historical Dictionary of the Belarusian Language” in 37 Volumes

#### DEPARTMENT OF AGRARIAN SCIENCES

- 288 Spring Barley Variety Raider
- 290 Spring Wheat Variety Ladia
- 292 Asima Soft Winter Wheat
- 294 Spring Triticale Variety Dobroye
- 296 Resoiler Microbiological Inoculant
- 298 Technological Regulations for Fighting Against the Quarantine Pest – Western Corn Rootworm (*Diabrotica virgifera virgifera* Le Conte)
- 300 Database on the Distribution of Dominant Pests in Sorghum Crops Cultivated in Different Agroclimatic Zones
- 302 Ripper-Mole Cultivator RMC-0.7 with a Depth Limiter
- 304 Fibre Flax Variety Everest
- 306 Oil Flax Variety Slavyanin
- 308 Smart Farm
- 310 Intrabreed Type of Pigs “Pripyatsky” in the Landrace Breed
- 312 Breeding Type of Pigs of Yorkshire Breed “Dvinsky”
- 314 Methodology for Creating Expression Vectors of Crispr/Cas System Components Aimed at Improving the Economic Traits of Farm Animals Using Genome Editing Techniques
- 316 System and Perspective Model of Breeding and Selection of Red Dairy Cattle in Belarus
- 318 Vaccine for Prevention of Pasteurellosis, Bordetellosis and Myxomatosis of Rabbits “RESPIMIX”
- 320 “Colitox-LT” Inactivated Emulsified Vaccine for Prevention of Colibacteriosis (Escherichiosis) and Klebsiellosis of Cattle
- 322 Veterinary Drug “TRICLAMIZOL”

324	Technology of Application of Microbial Preparation of Complex Action in Fish Ponds in Order to Increase Concentration of Biogenic Elements During Cultivation of Cyprinoid Fish
326	Technology of Growing White Amur Planting Material Providing Improvement of Production Indicators
328	Fish Hydrolyzate From Freshwater Fish Processing Waste
330	Device for Biometric Identification of the Premastitic Condition of the Udder of Dairy Herds Cattle
332	Specialized Food Products with Reduced Phenylalanine Content
334	Diffusion Juice Treatment Technology Using Electro-Membrane Processing
336	Line of Functional Specialty Meat-Based Food Products with Reduced Phenylalanine Content
338	Technologies for Production of Dry and Frozen Concentrated Starters for the Production of Dairy Products Based on Domestic Start Cultures from the Republican Collection of Industrial Strains of Starter Cultures and Their Bacteriophages
340	Dry Dairy Product with a Reduced Protein Content
342	Methodical Recommendations for Determining the Criteria for Classifying Food Products and Agricultural Raw Materials as High Value-Added Goods

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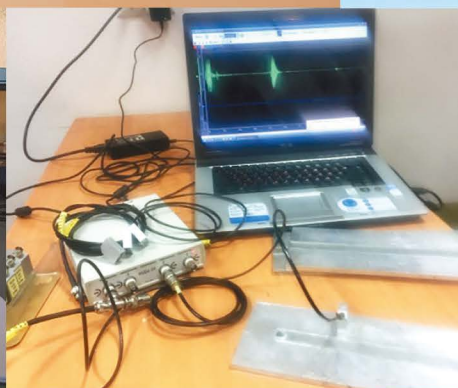
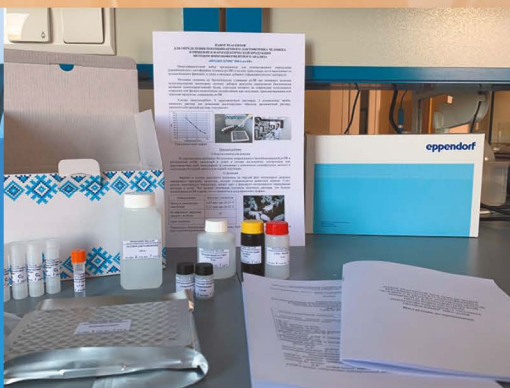
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