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The book includes the proceedings of the 6th Belarus-Korea Forum “Science. Innovation. Production” on the areas of Nanotechnology, Biotechnology; as well as the materials of the Seminar on scientific and technical information with KISTI (Korea Institute of Science and Technology Information).

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CONTENTS

NANOTECHNOLOGY	7
<i>V. Abashkin</i> MODIFIED GOLD AND SILVER NANOPARTICLES AS POTENTIAL GENE DELIVERY VECTORS.....	9
<i>Jinho Ahn</i> NEW TECHNOLOGY FROM LAB TO FAB: A CASE STUDY ON EUV LITHOGRAPHY.....	10
<i>Yu. Aliakseyeu, A. Korolyov, V. Niss, A. Parshuto</i> PLASMA-ELECTROLYTE POLISHING OF TITANIUM ALLOYS IN LOW CONCENTRATED SALT SOLUTION BASED ELECTROLYTE..	11
<i>V. Bezborodov, S. Mikhalyonok, N. Kuz'menok, A. Arol, V. Lapanik</i> MODERN TRENDS OF THE CREATION OF NEW MATERIALS AND DEVICES.....	13
<i>V. Bondarenko</i> FORMATION, PROPERTIES AND APPLICATION OF COMPOSITE MATERIALS BASED ON POROUS SILICON AND METALS.....	15
<i>V. Borisenko</i> EDUCATION AND RESEARCH ACTIVITY IN THE DEPARTMENT OF MICRO- AND NANOELECTRONICS OF BELARUSIAN STATE UNIVERSITY OF INFORMATICS AND RADIOELECTRONICS.....	16
<i>Hwang Chanyong</i> CURRENT STATUS OF SPINTRONICS RESEARCH OF KRISS.....	17
<i>S. Fisenko, Yu. Khodyko, V. Saverchenko</i> NANOPARTICLES PRODUCTION VIA SPRAY PYROLYSIS. HEAT AND MASS TRANSFER AND PHYSICAL-CHEMICAL TRANSFORMATIONS.....	18
<i>Sang Soo Han</i> FIRST-PRINCIPLES GUIDED DISCOVERY OF NOVEL BIMETALLIC NANO-CATALYSTS FOR H ₂ O ₂ DIRECT SYNTHESIS.....	20
<i>A. Karachun</i> SYSTEM OF DIAGNOSTICS OF TECHNICAL CONDITION OF NANOSIZED ELECTRICAL SYSTEMS.....	21
<i>V. Lapanik, A. Lugovsky, S. Timofeev</i> NEW WAY TO CREATE HIGH-SPEED LCDS BASED ON THE USE OF MODIFIED NANOMATERIALS.....	23

<i>Jinwoo Lee</i> DIRECT ACCESS TO FUNCTIONAL POROUS MATERIALS FOR HIGH PERFORMANCE LITHIUM-SULFUR BATTERIES.....	25
<i>I. Lutskaya, N. Novak</i> NANOMATERIALS IN THERAPEUTIC DENTISTRY.....	26
<i>A. Murashkevich, O. Alisienok, I. Zharskiy, M. Novitskaya</i> TITANIA SOLS AS PRECURSORS OF COMPOSITE MATERIALS FOR PHOTOCATALYSIS, ELECTORRHEOLOGY, SORPTION.....	28
<i>Jae Yong Song</i> CURRENT/FUTURE NANOTECHNOLOGY POLICY AND R&D IN KOREA.....	30
<i>E. Stepanova-Parshuto, A. Parshuto, I. Smyaglikov</i> FORMATION OF CORROSION RESISTANT OXIDE COATINGS ON ALUMINUM-SILICON ALLOYS.....	31
<i>V. Vasilkevich, R. Bogdanov, L. Bondarenko</i> TOPICAL ISSUES OF HYGIENIC SAFETY IN PRODUCTION AND APPLICATION OF NANOMATERIALS.....	33
<i>V. Yakovtseva, D. Shimanovich</i> NANOPOROUS ALUMINA MEMBRANES FOR LIGHT ENHANCEMENT IN LCDs.....	35
BIOTECHNOLOGY	37
<i>N. Akulich, V. Syakhovich, S. Beliaev</i> THE TECHNOLOGY OF DETECTION OF STORED BLOOD QUALITY...	39
<i>A. Aldoshin</i> MEDICINE CUSTOMIZATION THROUGH BIGDATA INTEGRATION....	40
<i>I. Bobkova</i> OPPORTUNITIES FOR ULTRASOUND AND LOW-INTENSITY LASER IN THE TREATMENT OF PERIODONTAL DISEASES.....	42
<i>Park Byoung Chul</i> NEW CONCEPT PLATFORM TECHNOLOGY OF DRUG DEVELOPMENT FOR VARIOUS DISEASES.....	44
<i>M. Dudan</i> CREATION AND DEVELOPMENT OF ELEMENTS OF INNOVATIVE INFRASTRUCTURE OF PHARMACEUTICAL AND BIOTECHNOLOGICAL SPHERES IN THE REPUBLIC OF BELARUS.....	45
<i>Jae-Yean Kim</i> CRISPR TECHNOLOGY AND GENOME EDITING FOR NEW PLANT BREEDING TECHNOLOGY.....	47

<i>Seung-Goo Lee</i> ARTIFICIAL GENETIC CIRCUITS FOR HIGH THROUGHPUT DIRECTED EVOLUTION OF WIDE VARIETY ENZYME ACTIVITIES.....	48
<i>S. Maksimova</i> PROCESSING AND UTILIZATION OF ORGANIC WASTES WITH HELP BIOOBJECTS.....	49
<i>D. Nitkin, I. Lutsкая, T. Kalinina</i> THE LASER RADIATION EFFECT ON THE NEUROGENIC POTENTIAL OF MESENCHYMAL CELLS OF DENTAL PULP.....	51
<i>A. Prozhivalskaya</i> THE INFLUENCE OF BIG DATA IN THE BIOTECH INDUSTRY.....	53
<i>N. Pushkina</i> INVESTIGATION OF THE EFFECT OF MICROWAVES ON CORN SEEDS FERTILITY.....	55
<i>Y. Shlykova, O. Ignatovets, V. Leontiev, E. Feskova</i> STUDY OF ANTIOXIDANT ACTIVITY OF MEDICINAL PLANT EXTRACTS.....	57
<i>N. Voronova, R. Shulinski, Y. Bandarenka</i> NEW SCIENTIFIC APPROACHES TO ENVIRONMENTALLY FRIENDLY PEST MANAGEMENT.....	59
<i>Euijeon Woo</i> TYPE III CRISPR/CAS SYSTEM AND ITS APPLICATION.....	60
<i>Chao Yu, M. Shonina, A. Lagodich</i> THE CREATION OF GENETIC CONSTRUCTS FOR MODIFYING THE SHIKIMIC PATHWAY IN THE BACTERIA <i>BACILLUS SUBTILIS</i>	61
<i>Cheol-Heui Yun</i> FROM BASIC TO APPLIED SCIENCE IN IMMUNOLOGY.....	63
<i>S. Zybleva, S. Zyblev</i> THE RESULTS OF MONITORING THE B-CELL IMMUNITY IN PATIENTS AFTER KIDNEY TRANSPLANTATION.....	64
<i>S. Zybleva, S. Zyblev, P. Novikov</i> THE EFFECT OF IMMUNOSUPPRESSIVE THERAPY ON T-CELL IMMUNITY IN PATIENTS WITH KIDNEY TRANSPLANTATION.....	65
MATERIALS OF THE SEMINAR ON SCIENTIFIC AND TECHNICAL INFORMATION WITH KISTI (KOREA INSTITUTE OF SCIENCE AND TECHNOLOGY INFORMATION)....	67
<i>S. Bilyk, V. Kim, E. Marukovich, I. Sazonov</i> PROSPECTS FOR IMPROVING ELECTRONIC STABILITY CONTROL SYSTEMS OF VEHICLES.....	69

<i>A. Kalinin, N. Troshchaya</i> INTELLECTUAL PROPERTY POLICY: EXPERIENCE OF SEOUL NATIONAL UNIVERSITY.....	71
<i>N. Kisseleva</i> THE INFORMATION AND COMMUNICATION TECHNOLOGIES FOR SMALL BUSINESS DEVELOPMENT.....	73
<i>D. Nitkin, T. Kalinina, I. Lutsкая</i> INFORMATION AND COMMUNICATION TECHNOLOGIES TO IMPROVE POSTGRADUATE MEDICAL EDUCATION.....	75
<i>A. Podupeiko</i> INFORMATION AND COMMUNICATION TECHNOLOGIES FOR ORGANIZATION DEVELOPMENT.....	77
<i>N. Shumskaya</i> E-PORTFOLIO AS A TOOL FOR ORGANIZATION OF LIFE-LONG LEARNING.....	79
<i>V. Shuts, A. Shviatsova</i> CASSETTE ROBOTIZED URBAN TRANSPORT SYSTEM OF MASS CONVEYING PASSENGER BASED ON THE UNMANNED ELECTRIC CARS.....	81
<i>I. Ustsinovich</i> THE USAGE OF R&D STATE REGISTER FOR THE PURPOSES OF TECHNOLOGICAL FORECASTING.....	84
<i>I. Zubritskaya</i> THE METHODS AGGREGATED ASSESSMENT OF DIGITAL TRANSFORMATION MANUFACTURING INDUSTRIAL EFFECTIVENESS REPUBLIC OF BELARUS IN A GLOBALIZING WORLD ECONOMY.....	86

MODIFIED GOLD AND SILVER NANOPARTICLES AS POTENTIAL GENE DELIVERY VECTORS

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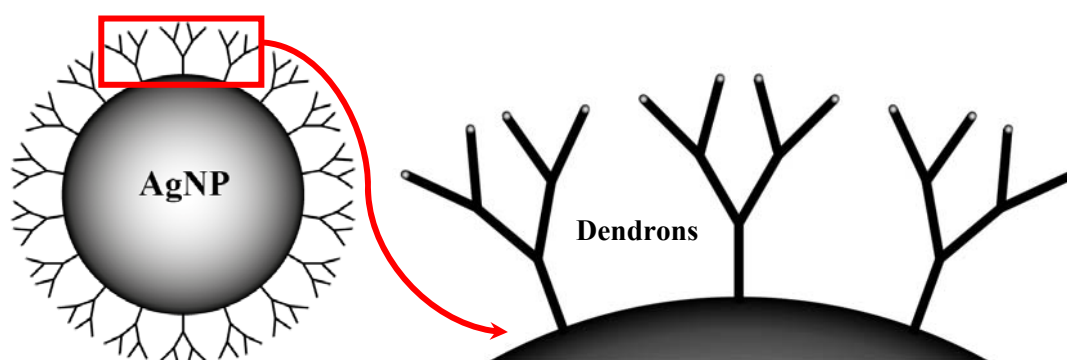
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Gold and silver nanoparticles are interested scientists for a long time. Over the past decades, many problems related to the control of synthesis, methods of functionalization and the search for optimal shapes and sizes of nanoparticles have been solved. Currently, gold and silver nanoparticles are attracting increasing interest in biomedical research. Their special properties suggest multitarget use. For example, they can be simultaneously used as an MRI contrast of tumors and a sensitizer for photodynamic therapy.

The functionalization of nanoparticles is an important aspect for reducing their various toxic effects, increasing the target efficiency (for example, accumulation in certain tissues), and increasing stability. One of the ways of functionalization is to modify the surface of a nanoparticle with dendrons (dendronization). Dendrons are special branching polymers that form structures similar to tree branches. Dendronization of nanoparticles allows them to effectively bind genetic material and deliver it to target cells. In addition, it has been shown that dendronization reduces hemotoxicity and cytotoxicity compared with the toxicity of nanoparticles or dendrons themselves.

It was also shown that dendronized gold and silver nanoparticles form stable complexes with various therapeutic oligonucleotides (miRNA, siRNA). Then, due to the positive charge of the terminal groups of the dendrons, the complexes effectively penetrate into the cells, releasing oligonucleotides, which ultimately have a therapeutic effect along one or another path.

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NEW TECHNOLOGY FROM LAB TO FAB: A CASE STUDY ON EUV LITHOGRAPHY

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Extreme Ultra Violet lithography (EUVL) is the most advanced patterning technology for semiconductor device production. The first experiment was performed in 1984 by Dr. Hiroo Kinoshita at NTT (Japan), but EUV lithography was just one of the candidates for advanced lithography technologies until the mid-1990s. EUV wave does not exist on earth, and is very hard to make. Once it is exposed to any material (including the air), it disappears due to strong absorption. In order to generate and manipulate EUV waves for semiconductor patterning process, drastic changes should have been made to every component in lithography system.

Due to the continuous efforts to solve the technical issues, EUV lithography is going to be inserted into high volume manufacturing from this year. It took more than 35 years to get ready for industrial application since the first pioneering studies on EUV lithography. The research on EUV lithography started from mid-1980s in Japan, U.S. and Europe. However, it was 1999 when the basic research on EUVL was started at a university lab. In 2002, a national project on EUVL was launched with the help of government funding, and a couple of research groups in academia and local industries started to build fundamental infrastructures for EUVL. A dedicated beamline in PAL (Pohang Accelerator Laboratory) was installed, and many research tools were built. That was about 15 years behind.

Through continuous research and investment, EUV lithography is now ready for the insertion into mass production of next generation semiconductor chips with a significantly improved performance. And this is already happening in Korea ahead of U.S., Japan and Taiwan. This is one of the best practices of R&D support by government at pre-competitive stage. The R&D funding by the government was an initiator for the long-term and massive investment in new technology by local industries. By the adoption of EUVL technology, Korean semiconductor industry will be reformed to be competitive in the field of foundry business (also fabless business) in addition to the memory business.

During the presentation, the short history of R&D investment on the new technology (EUV lithography) will be introduced and the benefits/limitation of the government support on R&D will also be discussed.

PLASMA-ELECTROLYTE POLISHING OF TITANIUM ALLOYS IN LOW CONCENTRATED SALT SOLUTION BASED ELECTROLYTE

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Titanium alloys are widely used at present in aircraft, nuclear energy, space technology, microwave technology, ultrasonic technology as well as in the manufacture of medical products. In most cases the production technology of such products involves the implementation of a quality polishing surface.

The disadvantages of mechanical methods are low productivity, susceptibility to the introduction of foreign particles, difficulties in processing complex geometric shapes. These materials are hard-to-machine for electrochemical technologies and processes of their polishing require the usage of toxic electrolytes. Traditionally, electrochemical polishing of titanium and alloys is carried out in acid electrolytes consisting of toxic hydrofluoric (20–25%), sulfuric nitric and perchloric acids. The disadvantage of such solutions is their high aggressiveness and harm to production personnel and the environment.

In order to reduce the environmental load, plasma-electrolyte polishing (PEP) is possible to use as an alternative to the existing methods of electrochemical polishing. The PEP technology is developed for polishing, deburring and cleaning of metal products and also for improvement chemical, mechanical and physical properties of the surface. In addition, PEP can be used for electrolytic heating and electrochemical-thermal hardening of the surface. The PEP is performed at a voltage above 200V.

This paper presents results of experimental study of new modes developed by us for plasma polishing and cleaning products of titanium alloys with the use of simple electrolyte composition based on an aqueous 4% ammonium fluoride solution, providing a significant increase in surface quality ensuring high reflectivity. Due to the use of aqueous electrolyte, the technology has a high ecological safety in comparison with traditional electrochemical polishing.

Fig. 1a shows experimental dependences demonstrating the dynamics in the surface roughness Ra changes while the titanium samples processing. From the obtained dependences, it appears that with the increase in operating voltage in the analyzed range (from 260 to 300V), reduction of the achievable values of the surface roughness parameter Ra is provided. According to the results of corrosion testing of titanium samples it was found that PEP has a significant effect on the change in their stationary potential and pitting formation potential in a 0,9% solution of sodium chloride. PEP with duration more than 3 minutes results in the transfer of a stationary potential from a region of partial passivity (the E_{st} of the initial sample is $-16,8$ mV) to the region of complete passivation (the E_{st} value is above 0,0 mV). PEP enhances the potential of pitting E_{pit} by 9–16%. The maximum value of the pitting potential $E_{pit} = 10,1$ V is reached at voltage of 300V, an electrolyte temperature of 90°C and duration of 5 minutes (Fig. 1b).

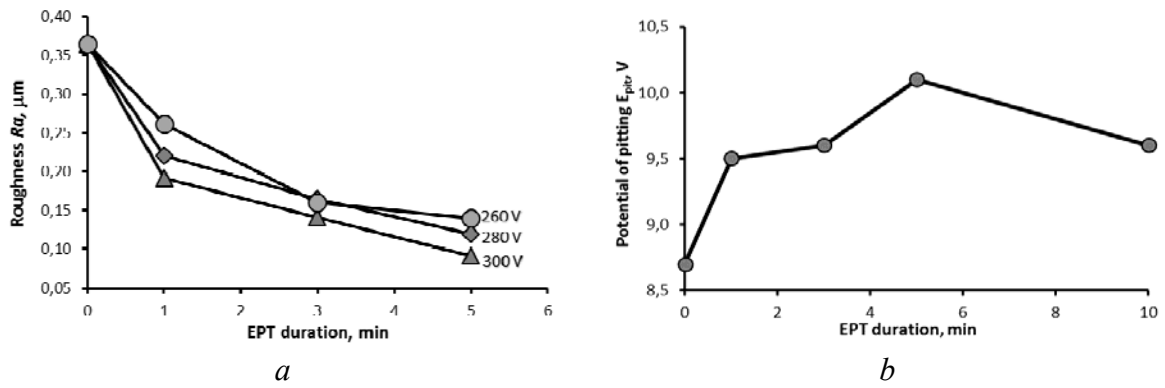


Fig. 1 – Effect of PEP duration on the surface properties:
a – roughness at different voltage; *b* – potential of pitting

Microphotographs of the surface of titanium samples before and after treatment are shown in Fig. 2. The surface of titanium before the PEP (Fig. 1a) is characterized by the presence of longitudinal stripes formed as a result of preliminary grinding of the samples. After the PEP the surface is smoothed out, only traces from the deepest scratches are observed (Fig. 2b).

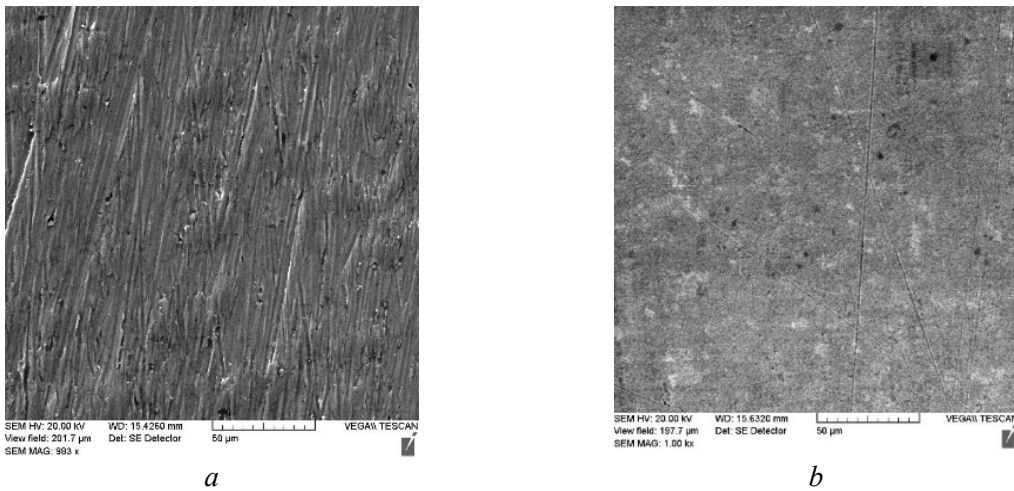


Fig. 2 – Microphotographs of the surface of titanium samples before and after PEP:
a – before the PEP; *b* –after the PEP

Based on the results obtained, processes of electrolytic-plasma polishing of a number of products made of titanium alloy Grade 5, used in medicine, have been worked out (Fig. 3).



Fig. 3 – Examples of the PEP medical products made of titanium alloy Grade 5

MODERN TRENDS OF THE CREATION OF NEW MATERIALS AND DEVICES

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The original methodology of the creation of Advanced Materials and Devices is considered. The proposed approach of design of new materials and anisotropic substances, modeling of various processes are based on the regularities of the evolutionary development of natural organic compounds; numerous data obtained in the last decades in the study of liquid crystals and ordered fluids; on the use of the anisotropy of the molecules of polyfunctional compounds for the design of new molecular structures (molecular engineering), films, liquid crystals [1], micelles, membranes, etc. and for the creation of anisotropic ensembles of molecules and biological systems.

The results of our investigations have shown that the combination of anisotropic materials, electrochemical techniques, nanostructured films and surfaces opens new possibilities of the creation of next generation displays, sensors, batteries with improved parameters; that anisotropic properties and good ordering of molecules of biopolymers give the opportunity of the preparation of original high ordered composites with a very wide spectrum of practical application.

We summarize and show here how the advanced both nonchiral and chiral nematic, smectic and other anisotropic compounds, batteries, sensors, photonic devices, displays can be successfully developed using the self-organizing systems, nanostructured surfaces, the transformations of the available 3,6-disubstituted cyclohex-2-enones (I), 5-substituted cyclohexan-1,3-diones (II), 3,5-disubstituted 2-isoxazolines (III), 1,2-disubstituted cyclopropanols (IV), substituted epoxyketones (V) and substituted cyclohex-2-enonyl 2-isoxazolines (VI) or other similar intermediates (Fig. 1).

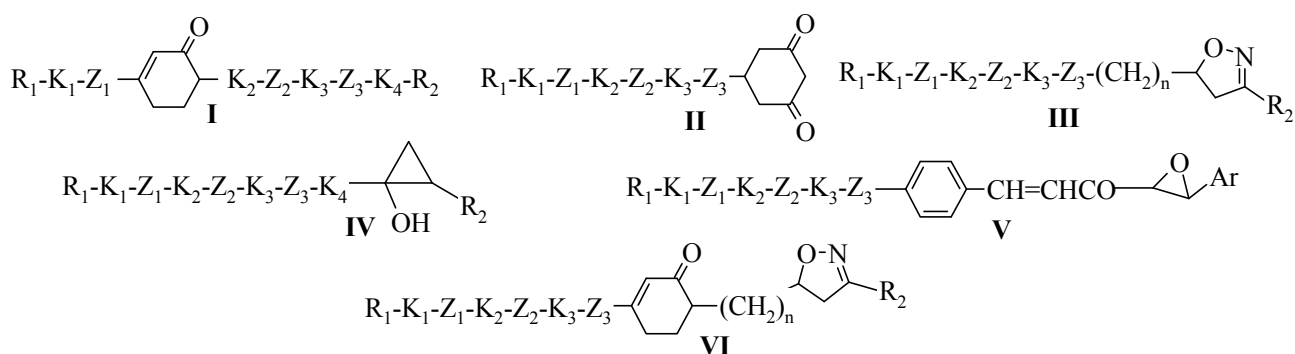


Fig. 1 – R_{1,2} = alkyl or alkoxy fragments, F, Cl, CN, CF₃, OCF₃ or chiral fragment;

K₁₋₄ = benzene or cyclohexane rings; n = 0-5;

Z₁₋₃ = single bond or CH₂CH₂, or other bridge fragments

It has been shown that different reaction possibilities for the functional groups in the central core or at the terminal position, and cyclohexenone, cyclohexan-1,3-diones, isoxazoline, cyclopropanol or epoxyketone fragments; diversity of the variants of the modification of these intermediates under the influence of different chemical reagents and reaction conditions allow the transformations to be achieved selectively and give the opportunity of preparing mesomorphic and anisotropic compounds with novel combinations of the structural fragments of molecules.

It should be noted that the corresponding intermediates (I-VI) in addition to liquid crystalline and anisotropic compounds for display application may be also transformed under the influence of water, mineral acids, amines or other chemical reagents into corresponding anisotropic α -diols, or halogenehydrines, or amino alcohols, or water soluble salts, or metal complexes.

This allows in addition to prepare anisotropic surface modified polymers as the result of the bond formation between polymer activated centers and the functional groups of the unsaturated epoxy- and vinyl ketones.

The presented results also demonstrate that the combination of anisotropic materials, nanostructured films and surfaces, which are characterized by the ordered relief structure, opens the new approach of the creation of next generation of high quality displays with improved parameters.

Moving from individual LC molecules to anisotropic supermolecules, supramolecular chemistry and anisotropic ensembles, Science has come close to **anisotropic materials Science and self-organizing systems**.

We propose to use of anisotropy of molecules and the self-organized systems and processes:

- for the preparation of advanced materials (new classes of complex organic molecules, coordination compounds, composites, biochemical synthesis);
- for the development of batteries, sensors, photonic devices, displays;
- for the creation of devices based on anisotropic molecular ensembles (molecular electronics);
- for simulation and investigation of biological processes.

It is obvious that our proposed methodology is original and creative, has a number of distinctive advantages in comparison with the well-known methods of obtaining the analogous matters and structures, modeling of biological systems; and can be successfully used for the creation of next generation of materials and displays with a very wide spectrum of practical application.

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FORMATION, PROPERTIES AND APPLICATION OF COMPOSITE MATERIALS BASED ON POROUS SILICON AND METALS

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Semiconductor silicon is a main material of semiconductor electronics and one of the most successful artificial material created by man. Physical properties of silicon are very well studied and, to date, scientists have almost exhausted the possibilities of changing these properties by traditional methods based on implantation and diffusion of desirable elements in silicon. In this regard, there is a great interest in finding new methods for creating silicon-based composite materials exhibiting properties that silicon does not have at all (for example, magnetism) or these properties are very weak (for example, luminescence). Such composite materials have been identified as a new solution for a significant expansion of the functional abilities of silicon to create new systems consisted of opto- and magnetoelectronic devices integrated with electronic circuits on the silicon wafer.

This presentation is a review of the research of our group aimed at developing a simple and efficient technology for the synthesis of composite materials that can be easily integrated with silicon wafers. Our approach consists in the formation of pore channels in a silicon crystal that are directed perpendicularly from the surface to the depth of the crystal, and then filling the pore space with another material which provides the properties that silicon does not have.

Ferromagnetic metals nickel, cobalt and iron are introduced into the pore channels to impart magnetic properties to composite materials. To ensure the luminescent properties, rare-earth metals and zinc oxide are deposited in porous silicon. Nanoparticles of noble metals silver and gold are formed on the surface of porous silicon and in the channels of its pores to ensure the plasmon properties of the composite material.

Structure of composite materials based on porous silicon and their physical properties, as well as possible applications are presented in this paper.

**EDUCATION AND RESEARCH ACTIVITY
IN THE DEPARTMENT OF MICRO- AND NANO-ELECTRONICS
OF BELARUSIAN STATE UNIVERSITY OF INFORMATICS
AND RADIOELECTRONICS**

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The review indicates bachelor, master and PhD programs and main directions of current research activity in the Department of Micro- and Nanoelectronics of Belarusian State University of Informatics and Radioelectronics.

The researches being performed are focused onto nanostructured materials and technologies of their fabrication. Fundamental electronic, optical and magnetic properties of two-dimensional crystals of transition metal dichalcogenides (MoS_2 , MoSe_2 , MoTe_2 , WS_2 , WSe_2 , MoTe_2) and their based heterostructures are theoretically simulated within ab initio approaches for applications in nanoelectronics and sensorics. Charge carrier transport mediated by spin effects is theoretically predicted and analyzed in new nanostructures for spintronics. Sol-gel technique and electrochemical anodization of metals are employed to fabricate porous materials: semiconducting oxides (TiO_2 , ZnO), insulators (Al_2O_3 , WO_x , Ta_2O_5) and graphitic C_3N_4 . These are tested for protective coatings, photocatalytic purification of water, protective optical coatings.

CURRENT STATUS OF SPINTRONICS RESEARCH OF KRISS

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Recently, Samsung, one of world-wide leading company in semiconductor memory device, has announced the mass production of magnetic random access memory(MRAM). Many people expect, in mid-20's, the limit of current semiconductor memory device will come. The future technologies replacing this memory have drawn a lot of attention and now MRAM becomes one of the strongest candidates.

The core technology of this MRAM is the magnetization switching, where several new techniques are still under development. I will introduce several topics such as magnetic skyrmion, domain wall motion etc. for replacing the current technique such as spin transfer torque.

As a national metrology institute in Korea, we are developing many characterization techniques for the spintronics industry. We will introduce several new techniques especially the microscope and magnetization dynamics tools.

We strongly hope the collaboration between Korea and Belarus in spintrocics or nano-scale magnetism research area.

NANOPARTICLES PRODUCTION VIA SPRAY PYROLYSIS. HEAT AND MASS TRANSFER AND PHYSICAL-CHEMICAL TRANSFORMATIONS

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One of most effective and cheap methods of nanoparticles production is the spray pyrolysis. Essence of spray pyrolysis is the obtaining nanoparticles from evaporating microdroplets of salts solutions. This continuous method is well suited for semi-industrial nanoparticles production.

A wide variety of different metals, metal oxides and alloys nanoparticles have been already obtained by researchers and engineers of Japan, South Korea, USA and many other countries [1]. Shape of this nanoparticles can be pure spherical, there are sometimes agglomerates of nanoparticles or a hollow submicron structures.

We present here the basic results of our decade long experimental and theoretical researches of the heat and mass transfer processes which determine the efficiency of the spray pyrolysis [2-3].

The central process is the evaporative cooling of femtoliter droplets of the salt solution. The rate of evaporative cooling depends on several important parameters as flow rates of carrier gas and sprayed solution flow rate, a wall temperature and the total gas pressure in the of an aerosol reactor. Typically cooling rate is about 10^4 K/s. It is worthy to emphasize that not only solvent molecules evaporate but also some molecules of intermediate substances in the solution. Spontaneous formation of molecules intermediate substances is due to salts dissociation and their interaction with a solvent.

During evaporative cooling of the droplet a supersaturated solution of initial salt is formed inside the droplet. The spatial scale of heat and mass transfer processes is several microns.

Supersaturated solution inside the droplet decays via nucleation. Finally, several nanosized clusters are formed. These clusters are situated stochastically in the droplet. Growth of these clusters is governed on the scale of several nanometers.

Chemical kinetics of a transformation of the original salt takes places on the interface of these clusters with solution. The rate of transformations depends on the evaporation rate of intermediate substances from droplet surface and a rate of solid state diffusion of atoms in the clusters. The interconnection of these two processes determines the rate chemical transformation during spray pyrolysis. The crucial circumstance that a diffusion coefficient in a solid phase is smaller of a diffusion coefficient in liquid on three orders of magnitude, therefore there are some limitations on efficiency of the method of spray pyrolysis. The efficiency decreases if the droplet radius is more than several microns. Typical engineering solutions of overcoming these misbalances are: increasing of the wall temperature in aerosol reactor or

decreasing total pressure in the aerosol reactor. Both engineering solutions increase the rate of the droplet evaporation.

The residence time of liquid droplets in the aerosol reactor effects on morphology of a nanoparticles ensemble in the droplet. The main physical processes are the Brownian diffusion and coalescence of nanoparticles. It was shown that if the residence time is above 10 milliseconds then the final product of the spray pyrolysis is a one submicron nanoparticle. The reason is that the vast majority formed nanoparticles are dissolved and products of these process deposit on the biggest nanoparticle. The Brownian diffusion distributes nanoparticles in the droplet practically spatially uniformly if droplet evaporation rate is not high one. It was established in our researches that for high evaporation rate the contribution of the Brownian diffusion is weak and hollow structures emerge due to the agglomeration of nanoparticles and subsequent growth near the droplet interface.

Further development of the spray pyrolysis method of nanoparticles production of different compositions will be based not only technical experiments, but on deep understanding of all heat and mass transfer processes, which open ways for the full control of this method and its possibilities.

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FIRST-PRINCIPLES GUIDED DISCOVERY OF NOVEL BIMETALLIC NANO-CATALYSTS FOR H₂O₂ DIRECT SYNTHESIS

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The direct synthesis of hydrogen peroxide (H₂O₂) from H₂ and O₂ represents a potentially atom-efficient alternative to the current industrial indirect process. And, Pd has been currently used as an efficient catalyst for direct H₂O₂ synthesis, although it has not been commercialized yet due to its expensive cost and still unsatisfied catalytic performances. In this regard, it is imperative to discover an inexpensive alternative with a superior catalytic property. For this purpose, we have designed several bimetallic catalysts replacing Pd through first-principles calculations, in particular, a high-throughput approach combining a calculation automation. Moreover, the designed catalysts were experimentally confirmed.

Electronic structure of a material is one of key features to determine catalytic properties as like *d*-band center theory. In the extension line of the theory, we screened 4350 bimetallic alloys by first-principles calculation and calculated similarities of their electronic densities of states (DOS) by comparing with that of Pd. Then, we filtered 10 potential catalysts (thermodynamically miscible) with the highest DOS similarities. And then, we synthesized the 10 candidates and experimentally measured their catalytic properties for H₂O₂ direct synthesis. After the experimental confirmation, it is found that, of the 10 candidates, three bimetallic alloys indeed show similar or superior catalytic properties to Pd. In addition, we suggest a new design scheme using “immiscible” bimetallic systems based on first-principles calculation, and the scheme is also successfully confirmed by an experiment. In this talk, I will also discuss the scheme.

Acknowledgment

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SYSTEM OF DIAGNOSTICS OF TECHNICAL CONDITION OF NANOSIZED ELECTRICAL SYSTEMS

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The development of nanoelectronics associated with the advent of transistors and other elements with characteristic topological dimensions of less than 100 nanometers, foreshadows the emergence of complex electrical nanosystems [1]. When designing any electrical system is always a question of its safety. Nano-sized electrical systems will also be subject to the occurrence of failures in them associated with short circuits and breaks in conductive channels.

One of the latest developments to ensure the safety of electrical circuits is electric network protection automatic (gas stations). Such a protective device is necessary in any electrical circuit, as it protects against various emergency situations [2]. The operation of such machines is associated with electromagnetic and thermal processes occurring in them. The implementation of gas stations operating according to generally accepted principles in nanoscale systems is currently not possible.

Using the apparatus of Boolean functions and transistor - transistor logic (TTL) [3], a system for determining failures of a nanoscale electrical system and an algorithm for its operation can be quite simply constructed.

In determining the diagnostic features of the technical state, it was taken into account that all disturbances in the nano-sized electrical system can only be associated with failures in its elements. Therefore, this condition is necessary and sufficient to address the issue of system performance.

To diagnose the state of the system is determined by the minimum set of diagnostic features. For this purpose, a diagnostic matrix of the system states is compiled, which provides the possibility of solving the diagnostic problem with the required accuracy. The main diagnostic signs of the main malfunctions of the system such as a short circuit and (or) break of the conductive channel are the expressions:

$$X_1 = \begin{cases} 1, \frac{dU}{dt} > 0; \\ 0, \frac{dU}{dt} = 0; \end{cases} \quad X_2 = \begin{cases} 1, \frac{dI}{dt} > 0; \\ 0, \frac{dI}{dt} = 0. \end{cases}$$

To simplify the synthesis of the optimal algorithm of the system for detecting failures from unacceptable voltage deviations due to the occurrence of states, the initial diagnostic matrix is transformed: indistinguishable states are combined in each of the groups that characterize the technical condition of the system. The simplified state table is a logic diagram of the failure detection system.

The possibility of implementing the simplest AND-OR logic elements on field-effect transistors makes it possible to build a non-spinning protection system for electrical nano-sized AC systems.

The elements for the protection system are silicon MDP – nanotransistors manufactured according to the technology "silicon on dielectric" (KND). This technology is considered by all leading electronic firms in the world as the basis for creating ultra-high-speed systems operating in the frequency ranges of tens and even hundreds of GHz at a supply voltage of a fraction of a volt. To create such structures, currently in industry widely used technology "isolation hidden oxide" – SIMOX, which allows to obtain a deeper layer of dielectric (SiO₂) under the surface of silicon implantation of oxygen ions.

Thus, a system built on nanotransistors using TTL and a device of Boolean functions allows one to determine failures in nanoscale electrical systems.

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NEW WAY TO CREATE HIGH-SPEED LCDS BASED ON THE USE OF MODIFIED NANOMATERIALS

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Diamond is one of the most popular materials which can exist in the form of nanoscale particles. Special class of nanodiamond material with characteristic sizes of 4 to 5 nm, often called in the literature “ultradispersed diamond” (UDD) or “detonation nanodiamond” (DND), were produced by detonation of carbon-containing explosives.

For the functionalization of detonation nanodiamonds, we attached carboxylate groups by grafting. Activation of COOH-surface functionalized groups allowed attachment of various organic tails.

Dielectric and electro-optical properties of nematic liquid crystalline mixtures (LCMs) doped with modified DND (MDND) are investigated. It is established that the effect of MDND on the dielectric properties of LCMs depends on the size of nanoparticles and the type of rod-like elongated organic molecules attached to the MDND. It was found that nanoparticles of small size (4-5 nm) do not significantly affect the LCMs parameters. At the same time, MDND-based conglomerates with a diameter of about 50 nm or about 100 nm can increase or decrease the dielectric anisotropy and LCMs response time by 1.5-2.5 times, depending on the polarity of the tails.

The problem of reducing the optical response time in modern displays based on nematic liquid crystals has not yet been completely solved. This is especially important for displays with a vertical orientation of the molecules due to the fact that not many classes of liquid crystal compounds are characterized by negative dielectric anisotropy. To solve this problem, we changed the design of the LC cell and the molecular orientation method. For the orientation of liquid crystals, transparent films of anodized aluminum oxide with an ordered system of pores were used. The pores of the film were filled with MDND. Due to the combination of all these materials, the response time can be improved several times, and the viewing angle can reach 180°. Our results have confirmed that this idea can be used to make high-speed VA LCD with a wide viewing angle.

As mentioned above, a serious limitation to the use of nematic liquid crystals in high-speed electro-optical devices is their slow response time. Liquid crystal materials with ferroelectric properties are characterized by a very high switching speed due to the linearity of the electro-optical effect (in the microsecond range). However, the lack of a stable orientation due to its destruction, even with a small mechanical action, is the main obstacle preventing the commercialization of such devices.

To solve the above problems, we investigated the influence of graphene on the dielectric properties of liquid crystals, since the dielectric characteristics of LCs have the greatest influence on the threshold and dynamic parameters of various devices based on liquid crystals.

Graphene flakes were doped into nematic liquid crystals and ferroelectric liquid crystals, respectively. From the experiment, we found that the dielectric spectra of pure nematic composition and composition doped with graphene are almost identical, except for one effect. The addition of graphene reduced the dielectric anisotropy sign inversion frequency by 100 kHz. Study in this area is promising, since many research centers are actively involved in the development of dual-frequency LC materials, through the synthesis of new classes of compounds. It is an expensive and lengthy process. In our case, this problem can be solved more easily.

It was found that the addition of graphene significantly affects the dielectric properties of ferroelectric LCs, and also leads to an increase in spontaneous polarization and a decrease in viscosity. The addition of graphene increases spontaneous polarization by 20-25% and increases the tilt angle by 15-20%. In turn, these parameters have the greatest impact on the response time of the ferroelectric LCD (reduces the response time by 70-90%). Figure 1 shows that the cell with the addition of graphene FGL-1 is characterized by a significantly faster response time.

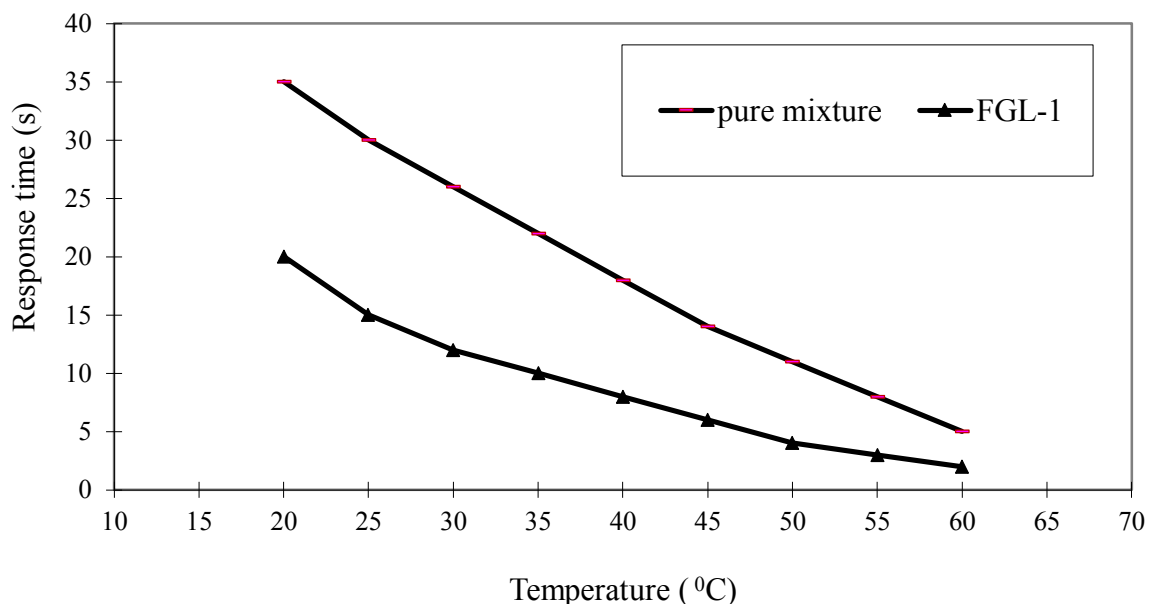


Fig. 1 – The response time of pure LC composition and LC composition doped with graphene

It should also be noted that the addition of graphene to ferroelectric compositions leads to the effect of bistability, improves orientation and resistance to mechanical deformations. Thus, we can conclude that graphene is promising as an additive to LC compositions for the development of high-speed and bistable displays.

DIRECT ACCESS TO FUNCTIONAL POROUS MATERIALS FOR HIGH PERFORMANCE LITHIUM-SULFUR BATTERIES

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Lithium-sulfur (Li-S) batteries are regarded as potential high-energy storage devices due to their outstanding energy density. However, the low electrical conductivity of sulfur, dissolution of the active material, and sluggish reaction kinetics cause poor cycle stability and rate performance. A variety of approaches have been attempted to resolve the above issues and achieve enhanced electrochemical performance. However, inexpensive multifunctional host materials which can accommodate large quantities of sulfur and exhibit high electrode density are not widely available, which hinders the commercialization of Li-S batteries. Herein, mesoporous carbon microspheres with ultrahigh pore volume are synthesized, followed by the incorporation of Fe-N-C molecular catalysts into the mesopores, which can act as sulfur hosts. The ultrahigh pore volume of the prepared host material can accommodate up to ~87 wt.% sulfur while the uniformly controlled spherical morphology and particle size of the carbon microspheres enable high areal/volumetric capacity with high electrode density. Furthermore, the uniform distribution of Fe-N-C (only 0.33 wt.%) enhances the redox kinetics of conversion reaction of sulfur and decreases the overpotential. The resulting electrode with 5.2 mg sulfur per cm² shows excellent cycle stability and 84% retention of the initial capacity even after 500 cycles at a 3 C rate.

NANOMATERIALS IN THERAPEUTIC DENTISTRY

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Advances in nanotechnology have greatly affected various areas of medicine. This is due to the possibility of using the substance at the scale of nanometers comparable to the size of biological structures.

In dentistry, the prospect of developing materials based on nanoparticles with unique properties opens up. The advantage of composites that include particles of ultra-small size in the range of 5-100 nm is their increased wear resistance, reduced shrinkage, reduced shrinkage, better Polish, more pronounced Shine.

Development using nanotechnology composites of domestic production that meet the requirements for modern restoration materials is very relevant and will be widely used in dental practice.

The purpose of this study is to develop a program and methods of medical testing of a new domestic light-curing composite material and conduct preclinical studies.

The study was carried out within the framework of research works on the topics "To Develop the composition and process of obtaining light-curing import-substituting cement and master its production" (together with the Belarusian state technological University», № state registration 20083532), "To Develop minimally invasive methods of treatment of dental hard tissues in aesthetic dentistry" in the subprogramme "New technologies for the relief of diseases" of the state scientific research program "Fundamental and applied science for medicine".

The studies were carried out using instruments and methods to determine the properties of nanoparticles, including scanning and transmission electron microscopes, laser devices.

For preclinical studies, samples of a new light-curing composite of Belarusian production were presented. For comparative analysis we used samples of nanocomposite material of a foreign manufacturer. The working properties, the state of the tooth and composite boundaries, as well as microhardness, adhesive strength and fluorescent properties of the samples were studied. The microhardness of the thin sections made from samples of the materials were determined by hardness testing "Micromet II" company "Buehler" (Switzerland) at the Institute of powder metallurgy of the National Academy of Sciences of Belarus. To assess the adhesion strength of material used universal testing machine "Instron 1195" (UK). In accordance with the methods of studying nanoparticles, studied the fluorescence spectra of samples on an automated spectrofluorometer SDL-2 At the Institute of physics named after V.I. Stepanov of the National Academy of Sciences of Belarus.

A comparative analysis of samples of domestic nanocomposite and imported analog, conducted according to the program of medical pre-clinical studies developed by us, showed that the domestic nanocomposite has all the necessary working and physical-mechanical properties for this kind of filling materials. Samples of

domestic material have the effect of "chameleon" and the color does not differ from the hard tissues of the tooth, due to the fact that they contain glass particles ranging in size from 25 to 75 nm. The matrix reinforced by nanoparticles has a unique chemical composition and is much more wear-resistant than the matrix of light and self-hardening materials. The advantage of nanocomposites is primarily due to the optical properties of nanoparticles, their better Polish and preservation of the polished surface for a long time.

The studied domestic nanocomposite had high indicators of "microhardness" (1875.00 ± 3.99 MPa) and "adhesive strength" (15.890 ± 0.008 MPa), similar to those properties of imported material (1870.00 ± 11.18 MPa and 15.930 ± 0.011 MPa, respectively).

A comparative assessment of the fluorescence spectra of the studied domestic and imported nanocomposites produced a fluorescence peak at a wavelength of 450 nm, which corresponds to the blue hue of the natural teeth of patients. The fluorescence intensity was registered in the range of 2 960-6 950 RH.unit, which also corresponds to the intensity of light emission intact teeth.

Thus, the comparative analysis of samples of the light-curing composite material of the Belarusian production and import analog, carried out in accordance with the program of medical pre-clinical studies developed by us, showed that the domestic composite has the working and physical-mechanical properties necessary for this kind of filling materials and is not inferior in quality to the imported analog, which allows us to recommend it for further development and development in production.

TITANIA SOLS AS PRECURSORS OF COMPOSITE MATERIALS FOR PHOTOCATALYSIS, ELECTORRHEOLOGY, SORPTION

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By changing the nature of initial components, the ratio of precursors, the heat treatment modes and using modifying and structuring components different in their nature, it is possible not only to control the textural characteristics of the obtained nanodisperse composites efficiently, but also to tune a phase composition, which also allows controlling their functional properties: photocatalytic, sorption, electrorheological.

Preparation of TiO₂ sol involved precipitation of hydrated titania from an aqueous solution of titanium tetrachloride by an ammonium carbonate solution followed by peptization of the precipitate in the presence of acid. The effect of precipitation temperature and pH on the phase composition of the obtained product and filtration rate, as well as influence of the nature of acid peptizator on sol formation rate and stable state duration were studied.

The particle size of titanium dioxide hydrosols less than 30 nm is maintained for 100–400 h (depending on the concentration of the solid phase and the acid-peptizer type). In this regard, as-prepared titania hydrosols are preferred to be used, but it is also possible to restore them from naturally dried xerogels (repeptization) that have the ability to peptize in water without introducing additional components. A feature of such xerogels is a significant increase in the size of the particles of the repeptized hydrosol. However, synthesis of hydrated titania at elevated temperatures (30–70°C) significantly suppresses the sol particles' tendency to grow, probably due to a higher degree of titania crystallization; and, as a result, its lower tendency to form aggregates in the process of drying. Hydrosols prepared from precipitates obtained at 70°C slightly change the size after repeptization in water. Photocatalytic activity of the “SiO₂ core – TiO₂ shell” composites based on such sols increases by 1.3 times with an increase in the synthesis temperature from ambientone to 70°C.

The initial “SiO₂ core – TiO₂ shell” composite used as photocatalyst contains silica particles coated with a layer of nanosized titania in the anatase structure (crystallite up to 40 nm). The particle size of the composite is 150–250 nm, while the shell consists of smaller particles of titania. The composite particles form complex aggregates of irregular shape, while maintaining a specific surface of 97– 265m²/g, sorption volume up to 0.26 cm³/g. The isotherm of low-temperature nitrogen adsorption – desorption for the “SiO₂ core – TiO₂ shell” composite is type IV with H3 hysteresis inherent in slit-shaped mesopores. It was shown that an increase in the photocatalytic activity of “SiO₂ core – TiO₂ shell” composite is achieved by introducing ammonium hydroxide ($n(\text{NH}_4\text{OH})/n(\text{TiO}_2) = 0.06\text{--}0.37$) and treatment at 750–800°C.

When sunlight is used as an activating radiation, the Rhodamine FL-BM decomposition rate constants decrease (approximately y 2 orders of magnitude).

However, the introduction of ammonium hydroxide in the composite allows increasing the photocatalytic activity of the material even under these activation conditions. A significant (up to 2.7 times) increase in the photocatalytic process rate is probably associated with a significant increase in the specific surface of the composite, changes in the density and structure of the aggregates.

The ERD filler was obtained by the sol-gel method, which includes the following stages: mixing the titania sol with solutions of modifiers (aluminum nitrate and phosphoric acid) and a structuring component (ammonium carbonate). At this stage, the sol-gel transition of the main component took place; the obtained gel was dried in a microwave oven, the dried product was ground in a planetary mill and then was calcinated.

There are two possible methods to improve the efficiency of titania as a filler of electrorheological dispersions. The first is to obtain the product in an extremely hydrated form. In this case, the electrorheological effect is activated by various forms of water bounded to the surface of titania particles. The second approach involves introduction of modifying and structuring components in the product preparation process. They must not only provide high dispersion of the product after high-temperature treatment, but also create structural defects efficiently responding to exposure to external electric fields. Therefore, we have chosen the second method – choosing modifiers and structuring components to activate the electrorheological performance of almost anhydrous fillers.

An important point is the nature and degree of interaction between the main components of composites and modifiers, which affects both volume characteristics and their surface properties that are extremely important in adsorption, catalysis, and electrorheology.

Due to their unique ability to form stable complexes with ions and neutral molecules, crown ethers is widely used in extraction processes, interfacial catalysis, organic synthesis, analytical chemistry, biology, and medicine. To increase the efficiency of physical crown ethers adsorption, a surface enriched with active groups is necessary. As crown ethers substrates, individual oxides of silicon, titanium, aluminum have a number of distinct advantages: high dispersion, mesopore order, thermal stability (less typical of titania), a wide variety of morphological forms: aero-, xero-, and coagels, precipitated powders, mesostructured substances, core/shell structures, nanotubes and some other related nanostructures.

Crown ethers immobilization on a surface of particles of a $\text{SiO}_2 - \text{TiO}_2$ composite has been shown to be leading to a significant increase in the adsorption capacity of the received organo-mineral composites in relation to a number of cations of metals from acid aqueous solutions.

CURRENT/FUTURE NANOTECHNOLOGY POLICY AND R&D IN KOREA

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In 2001, the nanotechnology in Korea was initiated by the Nanotechnology Development Promotion Act, which has driven the government investment on nanotechnology field and to establish the nano-infrastructure in Korea. During last two decades, there have been the drastic growth and outstanding outcome in nanotechnology of Korea, in the view of science and technology, including industry. The strategy in nanotechnology development is planned in detail, when being classified as nanomaterials, nano-devices, nano-bio, nano-energy/environment, nano-process/-measurement, and nano-safety. The status of government investment and key achievements is briefly introduced and some insights are discussed. In this talk, I would also like to present the current R&D policy of Korea and an outlook for next decade of nanotechnology in Korea, for instance, National Nanotechnology Initiative of Korea, National NT Roadmap, several national R&D projects, and etc. It is noted that the nanotechnology of Korea has simultaneously been developed in industry side as well as S&T field. Typical examples are presented with statistics related to the achievement in nano- S&T and nano-convergence industry. The nanotechnology of Korea is developing on the basis of open innovation with domestic and global partners, i.e., S&T colleagues and industrial collaborators.

FORMATION OF CORROSION RESISTANT OXIDE COATINGS ON ALUMINUM-SILICON ALLOYS

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High silicon aluminum alloys (silumins) exhibit a multitude of outstanding features, such as low density, high strength, small linear expansion coefficient, good dimensional stability, castability and machinability. Due to these superior characteristics, aluminum-silicon alloys are widely used as environmentally friendly structural materials for ships, airplanes and automotives. The presence of casting crusts on silumina surface prevents to high-quality painting of the metal surface, formation of chemical, electroplating and other coatings. To ensure reliable adhesion of functional coatings such as protective-decorative, electrical insulating, MW-conductive and others, it is required to remove the casting crust as well as to create an intermediate adhesive layer with a strong adhesion both to the metal and to the finishing coating [1–3].

To the date, one of the most important and desirable requirements to a metal is its corrosion resistance. One of the promising methods of formation corrosion resistant anodic oxide films is a method of high voltage electrochemical oxidation. Within this work thick corrosion resistant aluminum oxide films were obtained.

The composition of alloys are, wt%: 8.8 Si, 1.1 Fe, 0.2 Mn, 0.7 Cu, 0.2 Mg, 0.5 Zn and bal. Al (alloy 1) and 9.3 Si, 1.1 Fe, 0.9 Mn, 0.3 Cu, 2.2 Mg, 0.1 Zn and bal. Al (alloy 2). The test samples were cut as a circle of dia. 30 mm and 6 mm thick. Formation of oxide films were carried out under the following technological parameters: current density 3 A/dm²; duration 30 min, electrolyte temperature 20°C. The aqueous solution of sulfosalicylic acid (electrolyte №1) and aqueous mixture of tartaric and sulfuric acids (electrolyte №2) were used as an electrolyte.

The thickness of the oxide layer on the surface of the samples was determined by UNIT UT342 gauge, the principle is based on the use of an ultrasonic probe that sends the analyzed pulse through the coating. The echo signal is digitized and analyzed to determine the thickness of the film.

The results of thickness measurement are shown in Table1.


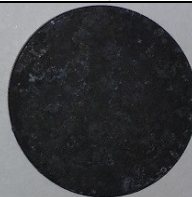



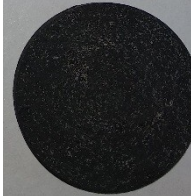
Table 1 – The coating thickness

Electrolyte	Thickness, μm	
	Alloy 1	Alloy 2
Electrolyte №1	40	36
Electrolyte №2	48	40

Corrosion testing of samples is carried out in the chamber Ascott ST 120ip. The essence of the method is to accelerate the corrosion process by increasing the temperature in the test chamber to 35°C and introducing into the atmosphere of the chamber 5 wt.% Sodium chloride solution, which is injected by the nozzle, thus creating salt mist (salt mist should have a dispersion of 1–10 μm (95% drops) and a concentration of 2–3 g/m³). Before loading into the chamber, samples are degreased with ethanol. The samples in the chamber are arranged so that they do not touch each other. The chamber ensures the maintenance of the set temperature, the creation of salt fog and the duration of the test according to the program specified by the operator. During the test, the pH of the prepared solution of NaCl (pH 6.0–7.0 at 25°C), the pH of the solution collected in collections in the chamber (pH 6.5–7.2 at 35°C), the rate of filling of the solution (1–2 cm³/h) and temperature in the chamber were monitored. Test results were evaluated visually.

The results of corrosion tests in salt fog for alloy 1 and alloy 2 are shown in Table 2. Samples of anodized alloys withstood corrosion tests.

Table 2 – The results of corrosion tests

Alloy	Bare alloy	Oxidized in Electrolyte №1	Oxidized in Electrolyte №1
Alloy 1			
	Suggestive corrosion	No corrosion	Extensive corrosion
Alloy 2			
	Suggestive corrosion	No corrosion	Separate corrosion sites

The use of the high voltage electrochemical oxidation method for anodizing of aluminum-silicon alloys allows obtaining the oxide coating with thickness of up to 48 μm at 30 minutes of treatment. The results of corrosion tests in salt mist showed that the resulting oxide films have a high corrosion resistance. It should be noted, that there is an optimal electrolyte composition that provides the outstanding corrosion results.

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TOPICAL ISSUES OF HYGIENIC SAFETY IN PRODUCTION AND APPLICATION OF NANOMATERIALS

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Nanotechnologies are the one of priority directions of the scientific and technical development of the Republic of Belarus. Scientists of the National Academy of Sciences of Belarus have developed “Concept for the development of nanotechnology and nanomaterials”. The Republican Association of Nanoindustry is successfully developing, which combines about thirty enterprises.

Nanoparticles and nanomaterials (NP and NM) are actively used in microelectronics, power engineering, construction, chemical and perfume and cosmetics industries, medicine and biology, agriculture, and also some other areas. Such intensive production and widespread use of new in their properties and biological effect nanoparticles and materials requires tackling a number of medical and biological problems. The most important issues are the study of patterns of biological effects manifestations of nanoparticles depending on their chemical nature, shape, size, surface area, charge and other physicochemical features of the structure, as well as dose, route of entry, concentration in target organs and duration of action.

In order to address the issues of hygienic safety, it is necessary to improve existing and develop new methods for studying the toxicity and danger of NPs and NM, taking into account their unique physical and chemical properties and modern international requirements. Research methods should be consistent with the concept of an “integrated research strategy” and be based on *in vivo* and *in vitro* studies. According to this experimental model, the main toxicological studies are carried out on warm-blooded organisms, but in order to limit animal testing, it is constantly necessary to search and implement alternative methods and test systems. The main objective of NM research is to study the systemic toxic effect on the body and specific (selective) effects on individual organs and tissues, as well as long-term effects.

To achieve success in the field of hygienic safety and risk assessment in the production and application of NP (NM) requires focus on solving the following problems:

- development of uniform criteria for the hazard of NP (NM) and methods for their determination/control;

- justification of safe levels of NP (NM) content in the habitat and production facilities;

- classification of NM by hazard classes in accordance with the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) and preparation of NM safety data sheets according to generally accepted rules for chemical products;

- development and implementation of accurate and informative instruments for determining and controlling NP (NM) in practice;
- assessment of the impact of NP (NM) on the health status of workers and population, identification of risk groups.

Currently, the Republican unitary enterprise "Scientific practical center of hygiene" is carrying out research on the features of biological action and specific (mutagenicity, carcinogenicity, genotoxicity) toxic effects of nanomaterials based on metals (the research is funded by the state and carried out within the framework of the industry scientific and technical program "Hygienic safety", 2019-2023). It is planned that the results of scientific research will contribute to the solution of the urgent problems of hygienic safety listed in the publication in the production and use of NPs (NM) and will minimize the risk of adverse effects on human health due to the development of nanotechnology.

NANOPOROUS ALUMINA MEMBRANES FOR LIGHT ENHANCEMENT IN LCDs

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1. Introduction. Nanochannel-array materials have attracted considerable scientific and commercial attention due to their potential utilization in magnetic, electronic, and optoelectronic structures, and devices. Nanoporous anodic alumina was originally considered as insulating component of semiconductor silicon microchips with metal aluminum conductors. It can be developed by electrochemical anodizing of aluminum to get free membranes with thickness up to 1 mm. Depending on the anodization regimes, pore size can be made from a few nanometers to hundreds of nanometers. Though structural properties and basic electrochemical routes are subject of extensive research during last five decades, only in the recent years unique optical properties of nanoporous anodic alumina have been discovered: a high transmission along pores with simultaneous high reflection from cut-edges [1], an optical birefringence [2], etc. So, nanoporous anodic alumina films are promising to control a light propagation in liquid crystal display devices.

2. Experimental. The 100 mm thick 40×48 mm² sized aluminum foils were subjected to the two-stage porous anodization from the front side of the sample to form layers of porous anodic alumina. The pore diameters and spacings are dictated by parameters of the anodization process, specifically by the electrolyte composition and the anodization voltage. The alumina film thickness is defined by the anodization time and the anodization current density. The rest un-anodized aluminum substrates were etched to provide free-standing films of porous alumina. We found that the additional removal of alumina bottoms in pores can be reasonable to get hollow cylindrical pores throughout the sample.

3. Results and discussion. The effect of the luminance enhancement was observed with the free-standing anodic alumina film by the naked eye because of anisotropic light scattering by spatially arranged nanometer-size pores. Fig. 1 demonstrates a high transparency of the free-standing anodic alumina film produced as compared to the reference Kimoto PF-90S M/M scattering film.



Fig. 1 – The opaque scattering commercial Kimoto PF-90S M/M film (left) and the anodic alumina film (right)

In more detail parameters of the free-standing anodic alumina films are described in the Figs. 2–3. Fig. 2 clearly shows a 5-fold higher transparency of the porous anodic alumina as compared to the reference Kimoto film at the normal incidence ($\alpha = 0$) and more than 2-fold enhancement for $\alpha = 20^\circ$.

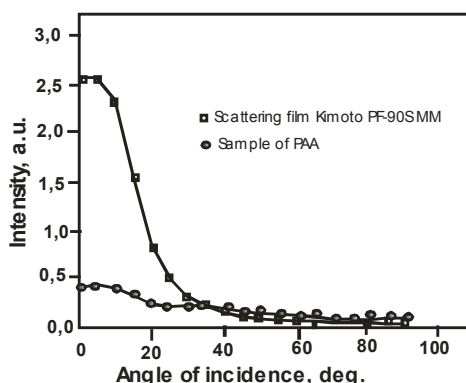


Fig. 2 – Intensity of light scattered normally to the sample plane versus angle of incidence

To get more detail on the light transfer by the anodic alumina oxide film, the light intensity enhancement from a flat white light emitting diode panel was examined. The porous anodic alumina film was placed between LEDs and a detector at a variable LED – film distance and the light intensity I_{PAA} was measured by the detector and compared with the light intensity registered without the alumina film. The 22% intensity enhancement was provided at the 100 mm distance between the sample and the LED panel as shown in Fig. 3.

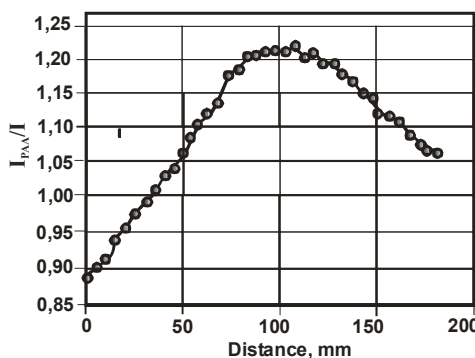


Fig. 3 –The ratio of light intensities with and without the alumina film between the LED panel and the detector depending on the distance between the film and the LED panel

Conclusions. The results obtained show that nanoporous structure of electrochemically anodized alumina films can be purposefully used to control light propagation, namely, to perform anisotropic light scattering in LCD backlight systems as well as potential modification of light polarization.

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THE TECHNOLOGY OF DETECTION OF STORED BLOOD QUALITY

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Blood transfusion is a procedure used in clinics for patients that undergo an operative intervention. Blood banks now consider six weeks to be the maximum permitted storage time of blood for use in transfusion, but recent studies have suggested transfusing blood stored for more than a few weeks has adverse effects in patients undergoing cardiac surgery or critical care. We propose to extend the new methods estimation of stored blood quality.

High concentration of glucose in blood storage medium promotes glycation and causes HbA1c and glycating compounds derived from glucose values to increase over time, which would predict that uncontrolled glycaemia leads to the formation and accumulation of advanced glycation end-products. In addition, nitric oxide is also important for delivery of oxygen by hemoglobin. Red blood cells carry nitric oxide bound to hemoglobin, and play a critical role in recycling the nitric oxide. Over time in storage, the nitric oxide is lost.

This method of detection of blood quality will a substantial effect on blood use. Management of blood storage will make medical sense and good economic sense.

MEDICINE CUSTOMIZATION THROUGH BIGDATA INTEGRATION

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In the past few years, the BigData science has become very popular in many major sectors of human life, and medicine has not become an exception here. The BigData technology refers to a huge amount of a variety of digital data sets that are collected, processed, integrated into existing systems and analyzed. Important features of the BigData are:

- 1) size/scale in terms of volume and quantity from the processed information, speed, diversity;
- 2) innovative, diverse, multi-tasking, timeliness, dynamism;
- 3) complexity and heterogeneity (structured, unstructured, semi-structured databases);
- 4) the information exchange and confidentiality.

Health care and its subsidiary sciences began to use actively data, since medical research forms and uses large, complex, multidimensional and diverse data sets for specific areas. Using a predictive analysis, you can also make a calculation of costs that are associated with admission rates while at the same time contributing to a more efficient distribution of staff and the pharmaceutical capacity of health care facilities.

The main step in the patient treatment is the disease diagnosis, the result of which is the diagnosis and treatment is prescribed. Thanks to the introduction of digital hospital records and their entry into BigData, this data will be easily accessible to doctors in the form of structured forms that will allow to take patient care to a new level.

To date, the death of patients from medical errors is estimated in thousands around the world. Medical institutions do everything possible to avoid this but despite this mistakes are inevitable because medical professionals can prescribe wrong treatment, medication or prescribe a medicine of an erroneous dosage. At the same time, the use of the BigData can significantly reduce the likelihood of medical errors that can occur with any specialist. This became possible due to the fact that the BigDate technologies can be used to analyze user data and, therefore, customize not only the medicine but also recommend the procedures and their duration for every individual patient.

At the same time, this technology can authenticate data and indicate false prescriptions so it can eliminate the possibility of an error and is supposed to save the lives of patients. On the other hand, it can be argued that this type of software can be really effective for doctors who have a large number of patients, thereby reducing the burden on staff. Also in medical practice it is not uncommon when due to the similarity of symptoms or inexperience of a doctor it is difficult to establish the correct diagnosis and effective treatment of the disease. For such cases, the BigData technology can also be used which is capable of processing a large number of significant amounts of data within a few seconds, and the specialist will be able to

find the appropriate treatment for each condition. Thus, the technology can provide specific, individual solutions for individual cases.

The BigData can influence all areas of human life from social sciences to political sciences, from financial industry to business, from medical science to public health, from health care to genetics and from personalized medicine to patient / user-oriented results. The BigData technology and the related practices open up new opportunities and promising directions in medicine development.

OPPORTUNITIES FOR ULTRASOUND AND LOW-INTENSITY LASER IN THE TREATMENT OF PERIODONTAL DISEASES

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Introduction. Chronic periodontitis is characterized by high prevalence and intensity in ambulatory patients. In addition, this disease is characterized by a long, persistent course and is poorly amenable to drug therapy. Often, periodontal diseases exist against the background of chronic somatic diseases, which exacerbates the severity of this pathology. Classical treatment of periodontitis, including medical and surgical methods of exposure, are not always effective.

Currently, in the complex treatment of periodontal tissue diseases in the absence of contraindications, low-intensity laser radiation (LILR) is used. When exposed to surface formations, it is preferable to use the radiation of the LILR in the red spectrum. One of the modern methods in periodontics is the use of the Vector-system (DurrDental, Germany). The technique is based on the combined effects of ultrasound and fine hydroxyapatite. Since the antibacterial and anti-inflammatory effects of the effects of the Vector system are mediated, it seems appropriate to combine the effects of ultrasound with hydroxyapatite and low-intensity laser radiation.

The purpose of this study is to increase the effectiveness of treatment of chronic periodontitis in patients with somatic pathology.

On the basis of experimental studies carried out within the framework of the State Scientific-Technical Program “Develop a surgical method for the treatment of diseases of periodontal tissues and apical periodontal using the drug hydroxyapatite and low-intensity laser”, we proposed a method for the treatment of chronic forms of periodontitis. The method is based on a combination of the effects of the Vector-system and LILR.

The method was used to treat 30 patients who were on outpatient treatment at the 8th City Clinical Dental Clinic of Minsk, with a diagnosis of chronic periodontitis of mild and moderate severity. The treatment was carried out according to the following scheme. On the first visit, professional oral hygiene was carried out, medical treatment followed by irradiation of the gingival margin of LILR in the red range of the spectrum (power 5 mW, MRP 16-20 mW/cm², exposure 40 seconds, radiation dose 0.6 J/cm²). During the second visit (after 1-3 days), periodontal pockets were processed with the help of the Vector apparatus and the laser effect was repeated. The course of treatment was individual and was 5-7 days. The comparison group consisted of 30 patients with a similar diagnosis who were treated according to the traditional scheme. The evaluation criteria were complaints, the clinical picture based on the definition of the GI index.

Results. In the main group, in the second visit, 9 people (30%) presented complaints of discomfort and bleeding gums when brushing their teeth. Their GI index values ranged from 1.85 ± 0.18 to 2.1 ± 0.2 points. The remaining patients

(70%) noted a significant improvement. Hyperemia, bleeding and painful sensations accompanying brushing decreased. The average value of the GI index was 1.58 ± 0.16 points. In the comparison group, improvement of the gum condition was noted by 4 people (13%), the average value of the GI index was 1.7 ± 0.17 points. In 87% of cases, patients did not observe significant changes. In the third visit, after using ultrasound with hydroxyapatite, only 2 patients (6.5%) from the main group complained of minor bleeding of the gums when brushing their teeth. In the vast majority of cases, complaints were absent, clinically the symptoms of inflammation were defined as slight hyperemia, and the average GI index was 0.96 ± 0.08 , which corresponded to a mild degree of inflammation. In the comparison group, the mean GI index was 1.72 ± 0.17 points (moderate inflammation). In 46% of cases, patients subjectively noted an improvement in the state of the gums, but an objective examination also revealed inflammation of moderate severity.

Findings. The use of the proposed method in patients diagnosed with chronic periodontitis allowed, on the second visit, to reduce the degree of gum inflammation in $70\% \pm 6.9$ cases. By the third visit, a positive result of treatment was registered in 93.5% of patients. The traditional scheme of treatment of this pathology made it possible to somewhat improve the condition of the gums, but an objective assessment of the clinical picture of the disease showed that there was moderate hyperemia, swelling of the gingival margin, and in some cases bleeding when probing.

Thus, the effect of LILR on the mucous membrane of the gums in the early stages of treatment, combined with the use of the Vector-system, can significantly increase the effectiveness of treatment of chronic periodontitis of mild and moderate severity.

NEW CONCEPT PLATFORM TECHNOLOGY OF DRUG DEVELOPMENT FOR VARIOUS DISEASES

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Drug development is a tedious job and it spend a lot of time and money. Many scientist and pharmaceutical companies are focused to new drug investment for inhibitors, blockers, and even accelerators to cellular signaling on life cycle. However most of them showed side effects, acquired immune resistances and limits of druggable targets. So we have been developed new paradigm of platform technology for successful drug development as target protein degradation. Those Protac and Degronimide are well known name as methods of target protein degradation strategy. With new E3-ligase and binder, we had been studied new drugs with well-known inhibitors but most of trials were failed. We have been optimized and examined those candidates *in vitro* and *in vivo* with target protein degradation strategy and finally got successful data. Now we strongly believe that this platform technology will very helpful for drug development and mankind.

CREATION AND DEVELOPMENT OF ELEMENTS OF INNOVATIVE INFRASTRUCTURE OF PHARMACEUTICAL AND BIOTECHNOLOGICAL SPHERES IN THE REPUBLIC OF BELARUS

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Experts believe that the primary internal factor that hinders transition of the Republic of Belarus to the path of innovative development is the country's established institutional environment. However, the Republic of Belarus has sufficient scientific and technical potential. And the main reason for the ineffectiveness of the Belarusian national innovation system is rooted in the fact that separate elements of this system appear to be incompatible with each other.

In the Republic of Belarus, the pharmaceutical and biotechnological spheres belong to high-tech industries. Therefore, competitiveness of enterprises working in these spheres is ensured by the wide use of these industries' scientific and technological achievements. The scientific potential associated with the industry is orchestrated by organizations under the National Academy of Sciences of Belarus, their production centers, organizations of the Ministry of Education and Ministry of Health. However, despite the relatively large number of innovative structures present in the Republic of Belarus, there are a number of challenges associated with their interaction.

Accelerated shaping of the high-tech sector in the Republic of Belarus could be ensured through implementation of the following activities:

- focusing the entirety of state authority related to state regulation of innovative development in one authorized body that would provide simplified access to financial and non-financial supporting tools for innovative enterprises responsible for the implementation of the state innovation policies. Absence of such a state body at the legislative level is a deterrent to the innovative development of the state;

- use of partnerships joining state and private sectors to identify commercial potential and promote scientific research. Small innovative entrepreneurship is capable of quickly bringing research and development to a commercial form and organizing production of innovations. Therefore, the state should spark the interest of representatives of small businesses in the implementation of innovations. The formation of state and private partnerships in Belarus is already underway. This is significantly different from the traditional full state ownership, which provides access to the sectors of economy and ensures long-term capital investments with a pre-agreed and guaranteed return rate;

- development of the National Science and Technology Park as the platform for innovative entrepreneurship activities, contributing to the emergence of new industries in the country. Creation of a science and technology park in the field of pharmaceuticals, nano- and biotechnologies in the Republic of Belarus should allow finding and accumulating available resources for the development of high-tech industries, ensuring implementation of the full innovation cycle of research and development all the way to the production of high-tech products. The main advantage

of the project will be the creation of a platform for communication between researchers, developers, entrepreneurs and investors, integrated into the global innovation system, as well as framing of a significant export potential and access to the new markets in the pharmaceutical, nano- and biotechnological industries;

– raising the competitiveness of universities through opening of engineering centers on their basis with specialization in the key activities where these universities already have superiority. Establishment of engineering centers at the leading technological and medical universities of the Republic of Belarus will ensure complementarity of science and technology and help enterprises in attracting young qualified personnel. The main advantage of creating such a center is the synergy of universities and real sector of the economy, which will reduce dependence on imported technologies, as well as integrate the results of scientific research of universities into the real sector of the economy and their commercialization. Engineering activity ensures cost effectiveness and overall efficiency of innovative project implementation by supporting all business processes through engagement of engineering organizations at each stage of the project. At the same time, with proper organization of work, project implementation timeframes can be reduced and investment risks decreased;

– creation of Belarusian multi-level system of continuous training, retraining and advanced training in new specialties of innovative activities, including pharmaceutical and biotechnological spheres;

– management of HR potential in the field of scientific, technical and innovative activities, increase of the managerial personnel's training level;

– development and state support of young people's inventiveness and startup movements.

To ensure effective development of the indicated activities in the Republic of Belarus, a number of legislative, regulatory, organizational, technical and economic measures are required.

CRISPR TECHNOLOGY AND GENOME EDITING FOR NEW PLANT BREEDING TECHNOLOGY

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The history of crop breeding in the past ten thousand years is closely in line with the history of human civilization. Breeding methods such as selection breeding, mutation breeding, and crossing breeding were carried out in the absence or little knowledge of genetic information ‘DNA or genome’. Whether natural or artificial breeding methods, the mutation was random and the farmer was able to select the seeds of the crops that showed good agricultural traits. Unlike the past, the breeding of the 21st century has made it possible to produce seeds with good agricultural traits as they design. The technologies that made this possible are transgenic technology (GM technology) and gene scissors (genome editing technology). In particular, the third-generation gene scissors, CRISPR-Cas9 technology, which has revolutionized current biotechnology and life sciences, has the advantages of being easy, fast, and economical compared to previous technologies and has been experiencing rapid artificial evolution by the worldwide laboratories. This lecture looks over past and current status of gene scissors technology and predicts future development trends.

ARTIFICIAL GENETIC CIRCUITS FOR HIGH THROUGHPUT DIRECTED EVOLUTION OF WIDE VARIETY ENZYME ACTIVITIES

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Synthetic biology inspires new engineering principles of biological systems, yielding advanced DNA-encoded-devices and new biological applications. For the last decade, we have focused on the development of genetically-encoded biosensors to monitor single cell enzymes, metabolites, and protein-protein interactions.

The biosensors were used as the critical tool to develop a variety of high throughput screening methods for enzyme functions. First, transcription factors were constructed to have a specific response against small xenobiotic chemicals such as phenolics. The transcription signal was regarded to indicate the presence of single cell enzyme activity because the xenobiotic chemicals could only be present only by the cellular activity acting on the supplied substrates. The approaches were confirmed to be very useful to find new enzymes working on lactams, isoprene, and others.

Flow cytometry and cell-imaging techniques were established to analyze the circuit behaviors, later to isolate the better hits from tremendous amounts of genetic diversities. Currently, we are applying the sense circuits for practical uses like the rapid profiling of million diversity of microbes or enzymes based on their catalytic functions.

We also tried to connect the sensors signal to the precise metabolic controls based on CRISPR interferences to regulate target metabolisms, which is expected to provide a synergistic effect with the biosensor circuits for the guided balancing of designed metabolisms.

PROCESSING AND UTILIZATION OF ORGANIC WASTES WITH HELP BIOOBJECTS

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The role of earthworms in the development of the physico-chemical and biological properties of soil and soil fertility is considerable and well-known. One of the important effects of earthworms is the production of large amounts of faeces or casts. Earthworm casts are the pool of concentrated nutrients. The content of total nitrogen, phosphorus, potassium and sodium are at a higher level in casts than in the surrounding soil. Vermitechnology (vermicomposting and vermiculture) is a biotechnical process in which earthworms are used to transform organic residues into more humified materials. Vermicomposting, the breakdown of organic wastes by earthworms, has become increasingly popular in recent years and there has been considerable commercialization of the process. In contrast with other traditional processes of utilization of organic wastes, vermicomposting takes advantages of the biological capabilities of earthworms and their activities to enhance the aerobic microbial decomposition of organic materials.

Vermitechnology (vermicomposting and vermiculture) is a biotechnical process in which earthworms are used to transform organic residues into more humified materials. Vermicomposting of agricultural and industrial wastes is not a traditional practice in Belarus.

The experimental design of our investigations is to work out different vermitechnologies of processing and utilization of organic wastes.

Almost any agricultural, urban or industrial organic wastes can be used for vermicomposting, but some may need form of preprocessing to make them acceptable to earthworms. Such preliminary treatments can involve washing, precomposting, macerating or mixing. Systems of vermicomposting include: outdoor or indoor windrows, wedge systems or indoor batch systems.

We use outdoor ground beds. The soil type, pH, organic matter content, soil moisture and any physical and chemical factors can act as limiting factors for earthworm survival. The processing of organic wastes by earthworms occurs most rapidly at temperatures between 15°C and 25°C and at moisture contents of 65-70%. The earthworms are also sensitive to certain conditions in the wastes. In particular, earthworms are very sensitive to ammonia (not more than 0.5 mg of ammonia per gram) and salts (not more than 0.5 %). In our investigation the content of ammonia was <0.5 mg/g and the content of salts was <0.5%. One of the most important characteristics of substrates supporting earthworm growth is the C/N ratio. The carbon to nitrogen (C:N) ratio was 20 good bulking characteristics (because of high straw content). In our investigations we found that 70-75% moisture contents produced the best growth and reproductive response. Worms can survive in a pH range of 5 to 9 (Edwards, 1998). Our investigations showed that the range pH of

6.5-7.2 was optimum. *E. foetida* reproduced very quickly. Our population doubled every 50-60 days, but only under optimum conditions. The density of population was 1 kg/m². To our mind, it is optimum density for reproduction. *E. foetida* produced 8 cocoons per earthworm per week (25 young earthworms).

We used several types of wastes: agricultural, trade and municipal. They are: cattle manure, pig manure, horse manure, poultry manure, rabbit manure, plant residues, beer pellet, sewage sediments, paper, leaves, grass. No mortality of earthworms was observed in any substrates. Total earthworm biomass increased in all substrates. Maximal number of clitellated earthworms was observed between the second and third months in all substrates.

We use in the vermin technologies *Eisenia foetida* (Savigny, 1826) (the tiger or brandling worm). It is world-wide species of earthworms. It has very high reproductive potential, has wide range of temperature tolerance and is less sensitive to density pressure.

Our final product after vermicomposting had a fine particulate structure, good water-holding capacity, high microbial activity and contained nutrients in a form ready available for plant uptake. The chemical nutrient contents of biohumus depended on material from which it is processed. But it contains the necessary elements for plants. The chemical composition of initial substrates and obtained biohumus were determined. Nutrients in biohumus were much higher than either ordinary garden soil and ordinary compost. Biohumus had higher N, P, K, Ca, Mg values than compost. pH of biohumus was 7.1.

We worked out technology of getting new humic liquid fertilizer using biohumus. It includes a complex of biologically active components in addition to the humic substances. The preparation (tradename "Fiterra") includes humates and fulvates Na and K, aminoacids, vitamins, phytohormones. The preparation improved seed germination; enhanced the growth of root systems: decreased the vegetative period by 2 -3 weeks and content of nitrates: increased the tolerance to diseases.

Flour from worms is a high quality of source of animal protein. Our investigations clearly indicated its efficiency in replacing fish flour and meat-bone flour in poultry, pig and fish feeds.

THE LASER RADIATION EFFECT ON THE NEUROGENIC POTENTIAL OF MESENCHYMAL CELLS OF DENTAL PULP

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Cell therapy is one of the promising areas of biotechnology development in medicine, which finds application in the diagnosis and treatment of cancer, autoimmune and other diseases. Methods for the production of stem cells capable of turning into any cells of an adult organism are being developed.

Japanese scientists have found that the pulp of wisdom teeth contains cell populations (MSC), which are completely identical to mesenchymal stem cells of the bone marrow. Stem cells, which demonstrated a high degree of stable development, reliability and stability were obtained from the pulp of these teeth by activating three genes. Thus, the results of the study showed a high efficiency of new methods for obtaining stem cells. Scientists consider the relative availability of obtaining the necessary material to be an important point in the study as the removal of wisdom teeth is a very common dental procedure.

At the present day mesenchymal stem cells derived from dental pulp (MSC DP) are recognized as an accessible and convenient source for autologous transplantation in regenerative medicine. The Journal of Biological Chemistry (USA, 2010) published the results of a study that states that wisdom teeth (third molars) contain valuable material for creating stem cells necessary for the treatment of serious and incurable diseases.

Stem cells derived from the pulp of wisdom teeth can be successfully differentiated into other cell types, for example, into cardiomyocytes – the main cells of the heart muscle that are used by cardiologists to treat heart disease (Kadar K., 2009). It is also shown that under certain conditions of in vitro induction MSC DP acquire the phenotype of nerve cells. The first information about the use of these cells in the treatment of middle cerebral artery occlusion in rats and stimulation of the proliferation and differentiation of neurons after transplantation of undifferentiated mesenchymal stem cells derived from dental pulp in the hippocampus of immunodeficient mice (neurotrophic effect) gives new possibilities for the potential use of mesenchymal stem cells derived from dental pulp in the treatment of cerebral apoplexy and neurodegenerative diseases. The use of standard protocols often leads to partial and reversible neurogenic differentiation of mesenchymal stem cells. Therefore, scientists' attention is focused on finding new methods that contribute to the complete differentiation of these cells in the neurogenic direction.

The positive effect of low-intensity laser radiation on proliferation, the formation of fibroblast colony-forming units, the secretion of growth factors, myogenic and osteogenic differentiation of adult mesenchymal stem cells is shown. Taking into account wide range of possible use of adult mesenchymal stem cells in the treatment of neurological diseases (injuries, neurodegenerative diseases, etc.), the

developed protocols for its extension and neurogenic differentiation are of great importance for its use in regenerative medicine.

Low-intensity laser radiation contributes to an increase in proliferative activity and contributes to stable differentiation of mesenchymal stem cells derived from dental pulp in the neurogenic direction under conditions of in vitro, which is of great importance for the production of neuron-like cells in regenerative medicine.

Enzymatic digestion method of dental pulp can be used to obtain mesenchymal stem cells derived from dental pulp. Culture-based, immunological, and molecular genetic methods of mesenchymal stem cells derived from dental pulp during growth and induced differentiation in the neurogenic direction in vitro are used.

Dose ranging and effect of low-intensity laser irradiation on mesenchymal stem cells, study of the effects of laser radiation on proliferative potential will allow to characterize the effect of low-intensity laser radiation on the differentiation potential of mesenchymal stem cells derived from dental pulp. It is expected that the use of laser radiation before neuroinduction will lead to a complete and permanent neurogenic differentiation of mesenchymal stem cells derived from dental pulp. Thus, a new method of increasing use efficacy of mesenchymal stem cells derived from dental pulp for autologous transplantation in neurological diseases can be developed. Obtained results can be used in practical dentistry, neurology, and maxillofacial surgery.

THE INFLUENCE OF BIG DATA IN THE BIOTECH INDUSTRY

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The biotechnology industry is ruled by data. The explosion of data in the last few years has been critical to the progress of technology and science in biotechnology. In its simplest form, biotech is the science of technology based on biology. It harnesses scientific cellular and biomolecular processes to develop technologies and products with the sole purpose of improving lives and the health of our planet. Over the last decades, humankind has leveraged biotechnology in agriculture, food production, and medicine but it is now inclusive of diverse scientific fields such as genomics, recombinant gene techniques, immunology, drug development, and more.

In recent years, Big Data analytics in the biotech industry has made the biggest impact in the following areas:

1. Genomics: Modern genomics relies heavily on Big Data analytics due to the vastness of available information in the field. Big Data has radically changed the industry by making the genomic technology commercially attainable, cost-wise and time-wise.

2. Drug discovery: The tedious and costly process of drug discovery within the biotech industry is simplified with the help of Big Data analytics which helps pharmaceutical companies analyze collections of millions and millions of compounds to build predictive models for drugs with a higher chance of success.

3. Agriculture: Environmental conditions change from season to season and from day to day. It is important for farmers to have accurate information to cope responsibly and intelligently with the changing environment. Big Data analytics contributes by analyzing GPS-fed information to implement precision farming. Additionally, analytics is also a significant contributing factor to genetic research to develop GMOs. These engineered crops can be altered more efficiently using data to improve yields and adapt in a fast-paced environment.

4. Health care: In the past, even though hospitals had access to a wide array of patients' data including diagnosis history, medical charts, nurse's records, genetic information and personal habits, there was no system that could effectively manage it all. However, big data analytics can now be deployed in the healthcare industry to analyze unstructured data.

An example of a big data use case in Korean healthcare comes from Samsung Medical Center (SMC). The center provides big data-driven personalized and precision medicine based on a patient's genetic makeup, medical history and lifestyle patterns.

This service uses big data technology to analyze a patient's entire medical record to formulate a personalized and optimized treatment plan as well as diagnose any other potential illnesses. The focus of this system is more towards managing and protecting patients' health, rather than just providing treatment.

In 2013, the SMC partnered with Daumsoft to develop a suicide forecast system. Predictors of suicide from social media data, such as consumer price index,

unemployment rate, weather, and well-publicized suicides, were used to monitor national suicide rates. The SMC's successful application of big data has inspired other hospitals such as Seoul National University Hospital and Ajou University Hospital to follow suit.

Big Data is generating results in different industries because innovative companies are using it to unlock value, trends, and insights. The biotech industry is quickly adapting to Big Data solutions because they have both public and private information sources that offer research, safety, and quality improvement opportunities. Part two will cover how Big Data is specifically impacting drug safety and research.

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INVESTIGATION OF THE EFFECT OF MICROWAVES ON CORN SEEDS FERTILITY

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Nowadays, experimental study of pre-sowing treatment of seeds is the subject of many researches. Among a variety of physical methods, exposition by microwaves of seeds of many cultures is a highly effective one. It is experimentally found that the microwaves of certain ranges and power stimulate the seed germination that in turn results in more productivity. Microwaves have ability to produces changes in the cell membrane's permeability. It also affects the cell growth rate as well as interaction with ions and organic molecules, like proteins. Physical methods of treatment offer good opportunities for substitution of chemical ones [1-3]. They are convenient for organic agriculture. The aim of present work is to enlarge previous experiments on stimulation effect of microwave treatment for on corn seeds fertility and investigation biochemical changes during this proses.

Groups of 50 seeds were subjected to each microwave treatment, for chosen exposure times and analogous groups were used as control. In order to estimate the influence of the microwave treatment on *Zea maize* seeds next criteria have been chosen: 1. Germination (G) of seeds in%, determined on 7th day as a ratio of the number of germinated to the total number of seeds; 2. Chromatographic analysis of the stems (SL) and roots (RL) components was performed using an Agilent 6850 gas chromatograph with a mass detector (GC/MS). Qualitative analysis was based on a comparison of the mass spectra of the components of methanol extracts with the corresponding data from the NISTO.5a library of mass spectra.

The results of the experiments for three varieties of cornseeds have been presented in Table 1 for microwave irradiation with output powers and time.

Table 1 – Germination of corn' seeds, exposed to microwave irradiation %

Sample	Daria	Polessky 103	Polessky 101
Control	93,3±2,0	68,6±3,0	52,4±2,0
Mode 1.1.	96,3±1,3	82,4±2,0	62,3±3,0
Mode 1.2.	94±0,3*	84,3±2,0	66,3±3,3*
Mode 1.3.	93,6±1,3	84,3±2,0	62,3±2,0
Mode 2.1.	95,3±0,7*	80,0±1,3*	64,0±3,0
Mode 2.2.	100±0,3*	88,6±1,3*	66,3±2,0*
Mode 2.3.	93,3±2,0*	80,0±2,0	68,6±2,0*
Mode 3.1.	93,3±2,0*	68,6±1,3*	60,1±,03
Mode 3.2.	93,3±2,0*	70,0±2,0	58,6±3,0
Mode 3.3.	93,3±2,0*	68,0±,03	52,4±3,3*

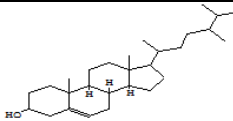
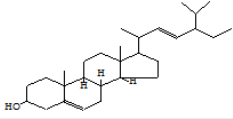
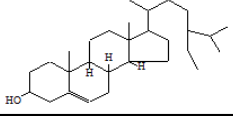
Superscript * corresponds to GD 1%, ns – not significant

Results are presented as average value ± standard error. The significance of differences GD P% is marked on the data in the table as a superscript. Data in Table 1

show the influence of microwave treatment on the first stages of plant development. It can be noticed that for microwave treatment with Mode 2.1. and 2.2. render the highest results for G of the studied varieties. This exposure time and power has shown stimulation effect. All data were significantly different from control.

Gas chromatography-mass spectrometry analysis of root extracts from germinating corn seedlings revealed a blend of 20 compounds from a variety of chemical classes, including small sugars, diacids, amino acids, inorganic compounds, and free fatty acids. The predominant group was steroid substances. Table 2 presents the number of steroid compounds in the roots of corn on the 12th and 14th day of growth after microwave seeds treatment.

Table 2 – The content of steroid nature metabolites in the corn roots on the 12th and 14th day of growth after pre-sowing seeds treatment with microwave

Formula	Metabolite	12 th day of growth			14 th day of growth		
		Control	Mode 2.2	%	Control	Mode 2.2	%
	campesterol CAS 474-62-4	6,0	6,5	+6,9	1,3	2,3	+66,7
	stigmasterol CAS 83-48-7	5,1	5,3	+3,6	2,3	4,3	+89,5
	g-stigmasterol CAS 83-48-7				1,3	2,2	+64,2

The investigation showed an increase of content of steroid substances in corn roots. Plant sterols and steroid hormones are compounds that exert a wide range of biological activities. They are essential for plant growth, reproduction, and responses to various abiotic and biotic stresses [4]. Therefore, it can be assumed that the stimulation of the growth of maize seedlings is due to the substantial accumulation of steroids. This result correlates with the observation in present work, having found that the treatment with lower output power demonstrates better stimulation of seed development and accumulation of steroids.

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STUDY OF ANTIOXIDANT ACTIVITY OF MEDICINAL PLANT EXTRACTS

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In the conditions of modern life there are a lot of negative factors affecting on the human body, which are able to disrupt the natural antioxidant system of human protection. That's why, antioxidants, drugs that can protect from the harmful effects of highly active oxygen and nitrogen compounds that causes oxidative stress cause a particular interest.

Medicinal plants occupy a special place among the antioxidants; the use of them in medicine is particularly relevant.

The main aim of the research is comparative analysis of antioxidant activity of medicinal plants extracts of CBG NAS of Republic of Belarus.

Research samples were medicinal plants: wood betony (*Stachys officinalis*), spring adonis (*Adonis vernalis*), serpent grass (*Persicaria bistorta*), estragon (*Artemisia dracuncululus*), oregano (*Origanum vulgare*), lavender, (*Lavandula officinalis*), common tansy (*Tanacetum vulgare*), garden sage (*Salvia officinalis*), licorice (*Glycyrrhiza glabra*) and pearl plant (*Lithospermum officinale*).

To determine the amount of biologically active substances (BAS) with reducing ability, a technique was used in which a solution of potassium permanganate in a sulfuric acid was titrated at room temperature by the research sample until the solution was discolored. For the quantitative characterization of AOA of the samples, the value B was introduced, which is the concentration of BAS with reducing ability of sample, used for titration of 1 ml 0,05 N solution of potassium permanganate, mg/g. The higher the value of B means the higher AOA of the research sample [1]. The results of concentration measuring of BAS with reducing ability are shown in table 1.

Table 1 – Concentration of BAS with reducing ability

Sample	B, mg/ml	Sample	B, mg/ml
Wood betony	26,5	Lavender	27,8
Spring adonis	20,0	Licorice	20,8
Serpent grass	25,0	Common tansy	25,0
Pearl plant	27,8	Garden sage	31,3
Oregano	50,0	Estragon	41,7

The results of the study showed that oregano (*Origanum vulgare*), garden sage (*Salvia officinalis*) and estragon (*Artemisia dracuncululus*) have the highest AOA. The next stage of research was determination of specific antioxidant activity (CAA) of chosen medicinal plants. CAA was judged by their ability to inhibit adrenaline autooxidation *in vitro* and thereby prevent the formation of active oxygen forms. The CAA of plant extracts was calculated as a relative value and determined by the ratio of extinctions at a specific reaction time [2]. The value of CAA more than 10%

indicates the presence of antioxidant activity. The results of the specific antioxidant activity determination of the studied medicinal plants are presented in table 2.

Table 2 – Specific antioxidant activity of medicinal plants extracts depending on exposure time

Studied medicinal plant	CAA, %		
	3 min	5 min	100 min
Oregano (<i>Origanum vulgare</i>)	84,0	91,0	69,2
Estragon (<i>Artemisia dracunculus</i>)	47,4	47,8	50,8
Garden sage (<i>Salvia officinalis</i>)	15,8	17,4	26,2

The results of research confirm that all studied plant extracts exhibit high antioxidant activity, but the greatest potential has oregano (*Origanum vulgare*), which can be used in the pharmaceutical industry for manufacturing medicinal drugs with high antioxidant properties.

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NEW SCIENTIFIC APPROACHES TO ENVIRONMENTALLY FRIENDLY PEST MANAGEMENT

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The biodiversity decline is a global warning trend which can be observed all over the world for the last 50 years. In the frame of this process the most unsettling phenomenon is a rapid decrease in the number and biomass of pollinators, which can lead to dramatic consequences as the flowering plant production is a very important part of the human food consumption.

Decline in the number of pollinators is believed to have several different reasons, but in many aspects, it is connected with an active insecticide usage during the last decades. Being not selective, modern insecticides cause severe damage to any insects in contact with plants, including beneficial ones, as well as water and soil organisms, predators, birds, fish and small mammals. In the light of CDB, all efforts of scientific communities and manufacturers should be directed towards developing new environmentally friendly approaches to control pests without damaging beneficial insects and other animals.

Biological selectivity of the insecticides is a very complex goal to achieve, because of the high plasticity of insect detoxification system and the common nature of detoxification enzymes in insects and other animals. For this reason, alternative methods of pest control such as, for example, bacterial symbionts management, biological agents releasing (parasitoids), pests' genome editing, etc. are coming to the front of the scene. However, today these new approaches are still remaining experimental but with a big potential for the future. The possible obstacles on the way of their development are, primarily, evolutionary plasticity of phytophages and their complex mutual relationships with endosymbiotic bacteria, which can influence pest resistance to temperature shock, insecticides and parasitoid pressure.

Studying aphid's hologenome, including all bacterial symbionts and all pull of genes involved in the process of detoxification, we suppose, can only give us a key for the building new tools for controlling aphids in open fields.

TYPE III CRISPR/CAS SYSTEM AND ITS APPLICATION

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The CRISPR-Cas system is an adaptive and heritable immune response that destroys invading foreign nucleic acids. The microbial CRISPR-Cas is currently classified into at least six different types, each with a signature protein including Cas10 of Type III. Cas9 (Type II) and Cpf1 (Type V) are now widely utilized as molecular scissors for targeted editing of genetic information. Recently, a novel signalling pathway was discovered in Type III system in that Cas10 subunit of the effector complex synthesizes cyclic oligoadenylates, which act as second messengers and initiate an RNAase activity of the immunity response.

The hyperthermophilic archaeon, *Thermococcus onnurineus* NA1, has the Csm complex of Type III system with six CRISPR loci in the genome. We were able to reconstitute an effector Csm complex of Type III-A in vitro that showed RNA targeting and RNA-activated single-stranded DNA (ssDNA) targeting activities. In the absence of an RNA transcript, it cleaved ssDNA containing a sequence complementary to the bound crRNA. In this presentation, the functional and molecular mechanism of Crispr-Cas systems is to be summarized with a focus on Type III system. Various potential application of Crispr-Cas system in gene editing, modulation of gene expression and molecular diagnostic is also to be discussed.

THE CREATION OF GENETIC CONSTRUCTS FOR MODIFYING THE SHIKIMIC PATHWAY IN THE BACTERIA *BACILLUS SUBTILIS*

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In the pharmaceutical industry, shikimic acid is used to create drugs, which is used in cancer chemotherapy, and is used for the treatment and prevention of diseases caused by the influenza virus, etc. [4].

In plants and microorganisms, shikimic acid serves as a precursor of a large number of functionally primary and secondary metabolites, such as: aromatic amino acids (phenylalanine, tyrosine and tryptophan), lignin, folic acid, tetracycline, ubiquinones, phenolic and carbolic compounds, alkaloids [3,5], therefore many of its derivatives are agricultural interest and are used as herbicides and antibacterial agents. Using of these compounds is based on their ability to block the shikimic metabolic pathway in organisms, because mammals and humans do not have the shikimic metabolic pathway, so without negative effect on mammals and humans [7]. For this reason, it is highly advisable to search for the alternative sources of this raw material and modify existing methods for its production.

The aim of the work was to obtain genetic constructs for modifying the shikimic pathway in the bacterial strains *B. subtilis*, which are capable to increase tryptophan synthesis and are potentially suitable for producing shikimic acid.

These bacterial strains were used in the work: *E. coli* - DH5 and XL1 – Blue; *B. subtilis* 168 trpC2. Strains from the collection of the Department of Genetics of BSU, characterized by an increased level of tryptophan synthesis: *B. subtilis* KMBU 2003, *B. subtilis* VKPM5434, *B. subtilis* VNII Genetics-15, and its derivatives C10, D3 and D4, obtained by the mutagenesis of the *B. subtilis* Genetics-15 strain and then selected mutants, which resistant to tryptophan structural analogues; and plasmids: pMTL21C, pLAV1, pAL1 and pAL2, pMUTIN4.

Bacterial cultures grow in liquid and solid nutrient medium have different compositions: LB or Spizizen minimal medium. Plasmid DNA from *E. coli* and *B. subtilis* bacteria were isolated by alkaline lysis [1]; to isolate plasmids from *B. subtilis* bacteria, the culture of plasmid-containing bacteria grows at 30°C. The total DNA of the bacteria was isolated by the method of phenol-chloroform extraction and used as a matrix for PCR.

The transformation of *E. coli* and *B. subtilis* bacteria cells, previously transferred to the state of competence, was carried out according to the recommendations given in the work manual [6], [2]. The transformation of *B. subtilis* strains with an increased level of tryptophan synthesis was carried out according to a modified method.

The chromosome fragment of the bacterial *B. subtilis*, containing the *tmrB* and *aroI* – genes, which were amplified using two pairs primers. For the ShikF-NotI and ShikR-BamHI pair, the following amplification modes were used: 94°C – 5 min (1 cycle); 94°C – 30 s; 52°C – 30 s; 68°C – 2 min (10 cycles); 94°C – 30 s; 54°C –

30 s; 68°C – 2 min (20 cycles); 72°C – 10 min. This primer contains recognizable sites of the restriction enzymes NotI and BamHI at the 5'-ends, respectively.

For this pair primer ShikF1-EcoRI and ShikR2-SacII, the following amplification modes were used: 94°C - 5 minutes (one cycle); 94°C – 30 s, 55°C – 10 s, 54°C – 25 s, 68°C – 2 min (10 cycles); 94°C – 30 s; 54°C – 30 s; 68°C – 1 min 30 sec (25 cycles); 72°C – 5 min. The primer contains EcoRI and SacII restriction sites at the 5'-ends, respectively.

Using the total DNA and the indicated primer pairs as the template for the PCR, the conditions for obtaining the target product were selected. To prove that the obtained amplicons have a similar structure to the expected, the obtained amplicons were verified using restriction enzymes HindIII and PstI, and then did the electrophoretic separation in an agarose gel.

By the Analysis of the electrophoregram shows that all the amplicons obtained are similar to the structure, but on the basis of the electrophoretic mobility can be divided into two groups. The first group can be attributed products obtained from total DNA of the following *B. subtilis* strains: VKPM5434, Genetics-15 D4 and KMBU 2003-2; the second group - VNII Genetics-15 D3, VNII Genetics-15 C10, KMBU 2003-1 and 168 trpC2. These differences may be a consequence of a series of mutagenesis, with the help, these strains used in the work were obtained.

Amplification products verified by restriction analysis were cloned into the pMTL21C and pMUTIN4 vectors. The selection of recombinant molecules was carried out using the transformation of *E. coli* bacterial cells with the ligation mixture, and with the key restriction sites, then selected on the medium with X-Gal, IPTG, ampicillin 50-100 µg/ml. From the obtained transformants, plasmid DNA was isolated and tested by RFLP method and sequence analysis. According to the results of the RFLP, a number of molecules were selected, in which contain the key determinants---restriction sites as expected.

As a result of this work, initial amplification products were obtained for the creation of genetic constructs, intended for integration into the composition of the bacterial chromosome. Among these amplicons, genetic polymorphism was identified, which may be the result of mutagenesis used in the preparation tryptophan producing strains. Using the obtained amplicons, an integration system has been created, for the controlled directional inactivation of the shimate kinase gene in *B. subtilis* bacterial cells. These results obtained are an important basis for the further design of producers.

FROM BASIC TO APPLIED SCIENCE IN IMMUNOLOGY

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The scientific mission of the Animal Immunology at Seoul National University for the last few years has been (1) Developmental and functional aspect of immune cells, (2) Host-microbiota interaction, and (3) Action mechanism of vaccine/adjuvant.

For the developmental and functional aspect of immune cells, B cells and T cells were investigated in immune systems of mouse and chicken; a number of genes and proteins during the developmental process and thereof function were changed.

Next, impact of probiotic mixture on the regulation of T cell balance (i.e., increase of regulatory T cells) coincident with the reduction of symptoms in mice with atopic dermatitis was evident that verify the theme of host-microbiota interaction. Furthermore, a model for microbiota-removed chickens suggested a regulatory role on the population changes of specific T cells where acetate is responsible for the induction of such cells in cecal tonsils.

Developing effective mucosal subunit vaccine and adjuvant has been unsuccessful mainly because of their insufficient memory T and B cell responses. Recently, we have introduced nano- and bio-materials that can enhance immunity and could serve as mucosal adjuvant for a subunit vaccine.

The goal of the Animal Immunology at Seoul National University, Korea are (1) increase of health status on animals and human, (2) enhancement of scientific knowledge on vaccine/adjuvant immunity, and (3) development of feed-supplement or therapeutic approaches through illuminating a host-microbiota interaction.

THE RESULTS OF MONITORING THE B-CELL IMMUNITY IN PATIENTS AFTER KIDNEY TRANSPLANTATION

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Objective: *to study the features of humoral component of immune system in patients after kidney transplantation.*

Material and methods. The dynamics of the subpopulations of CD19⁺, CD19⁺IgD⁺CD27⁻, CD19⁺ IgD⁺CD27⁺, CD19⁺IgD⁻CD27⁺, CD19⁺CD5⁺, CD19⁺CD40⁺, CD19⁺CD86⁺, immunoglobulins G, M, A, and C3, C4-components of complements has been determined in 94 recipients of renal allograft at 0, 1, 3, 10, 30, 90, 180 days. All patients received induction therapy of anti-CD25 monoclonal antibodies and triple immunosuppressive therapy, including calcineurin inhibitors, antiproliferative drugs (mycophenolate or azathioprine) and corticosteroids.

Results. The levels of CD19⁺IgD⁺CD27⁺ (non-switched memory B lymphocytes) and CD19⁺CD40⁺ (activated lymphocytes) were found to be significantly lower in the group of recipients at the pre-transplant stage than in the comparison group ($p = 0.026$ and $p = 0.031$, respectively). The level of CD19⁺IgD⁺CD27⁻ naive B-lymphocytes for 6 months after kidney transplantation rose progressively: on the 10th and 180th days it was significantly higher than in the comparison group ($p_{10} = 0.022$; $p_{180} = 0.008$). In turn, the number of switched memory B-lymphocytes (CD19⁺IgD⁻CD27⁺) practically did not differ from the comparison group over the entire observation period, but on the 180th day of observation it significantly decreased ($p_{180} = 0.003$). The negative dynamics of the IgG content was observed throughout the whole observation period ($p_1 = 0.0003$; $p_3 < 0.00001$; $p_{10} < 0.00001$; $p_{30} = 0.033$; $p_{90} < 0.00001$; $p_{180} = 0.0001$). The level of IgA in kidney transplant recipients over 6 months was lower than in the comparison group ($p_1 = 0.044$; $p_3 = 0.03$; $p_{10} = 0.11$; $p_{30} = 0.035$; $p_{90} = 0.018$; $p_{180} = 0.034$). The IgM content did not significantly differ from the comparison group up to 180 days and became significantly higher ($p_{180} = 0.048$).

Conclusion. Determined changes in the immune status characterized by a decrease in the switched memory B-lymphocytes CD19⁺IgD⁻CD27⁺ and immunoglobulins A and G and characterized by an increase in CD19⁺IgD⁺CD27⁻ naive B-lymphocytes and immunoglobulins M in recipients of allotransplant in the post-transplant period are a positive prognostic factor and can be recommended for immunological monitoring in the post-transplantation period.

THE EFFECT OF IMMUNOSUPPRESSIVE THERAPY ON T-CELL IMMUNITY IN PATIENTS WITH KIDNEY TRANSPLANTATION

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Objective: to study the effect of immunosuppressive therapy on $CD3^+CD4^+CD25^+$ (T-helper activated) and $CD3^+CD4^+CD25^{high}CD127^{low}$ (T-regulatory) lymphocytes in the recipients of the renal allograft.

Materials and Methods. The quantity of $CD3^+CD4^+CD25^+$ and $CD3^+CD4^+CD25^{high}CD127^{low}$ was determined in the peripheral blood of 43 recipients of the renal allograft with normal renal function by flow cytometry method on day 0, 1, 3, 10, 30, 90, 180, 360. All the patients received induction therapy with anti-CD25 monoclonal antibodies and three-component immunosuppressive therapy, including calcineurin inhibitors, antiproliferative drugs (mycophenolate or azathioprine), and corticosteroids.

Results. There wasn't detected any significant differences of the quantity of $CD3^+CD4^+CD25^+$ and $CD3^+CD4^+CD25^{high}CD127^{low}$ lymphocyte subpopulation in the group in the group of patients before kidney transplantation and in the group of healthy patients. On the first day after kidney transplantation the level of $CD3^+CD4^+CD25^+$ and $CD3^+CD4^+CD25^{high}CD127^{low}$ lymphocyte subpopulation was significantly decreased. The maximum decrease of quantity of $CD3^+CD4^+CD25^+$ cells was detected on the 10th day of follow-up. ($p_{0,10}$ Wilcoxon Matched Pairs Test = 0,018; $Z=2,38$) with the subsequent progressive growth of this subpopulation, and the decrease from the 3rd to the 10th day was no longer significant ($p_{10,30}$ Wilcoxon Matched Pairs Test = 0,332; $Z=0,986$). In addition, the tendency to decrease in $CD3 + CD4 + CD25 + highCD127 + low$ persisted for a longer period (up to 30 days). On the 90th day after the surgery the quantity of $CD3^+CD4^+CD25^+$ ($p_{0,90}$ Wilcoxon Matched Pairs Test = 0,600, $Z=0,524$) and $CD3^+CD4^+CD25^{high}CD127^{low}$ ($p_{0,90}$ Wilcoxon Matched Pairs Test = 0,248, $Z=1,153$) didn't differ from the level before transplantation. On the 360th day of the follow-up, there was detected a decrease in T-regulatory lymphocytes compared to the group of healthy patients (p Mann-Whitney U Test = 0,038; $Z=-2,071$).

Conclusion. The duration of the almost complete blocking of the IL-2 receptor on lymphocytes in patients after kidney transplantation receiving immunosuppressive therapy induction therapy with anti-CD25 monoclonal antibodies and three-component therapy with calcineurin inhibitors, antiproliferative drugs (mycophenolate or azathioprine) and corticosteroids is about 3 months. This should be taken into account when interpreting the results of an immunological examination of patients of this category. The quantity decrease in $CD3^+CD4^+CD25^{high}CD127^{low}$ cells at the 12th month of follow-up may be one of the effects of calcineurin

inhibitors and it can adversely affect the formation and maintenance of immunological tolerance in the posttransplant period.

Key Words: *kidney transplantation, lymphocyte subpopulation, CD25, T-regulatory lymphocytes.*

PROSPECTS FOR IMPROVING ELECTRONIC STABILITY CONTROL SYSTEMS OF VEHICLES

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Modern ESP systems include anti-lock braking system (ABS) and anti-slip regulation (ASR), which reduce slip of vehicle wheel contacts when braking and accelerating. As a result, the stability of a vehicle is increased. All ESP control algorithms are based on the well-known diagram showing the change of the adhesion coefficient of wheels (Fig. 1).

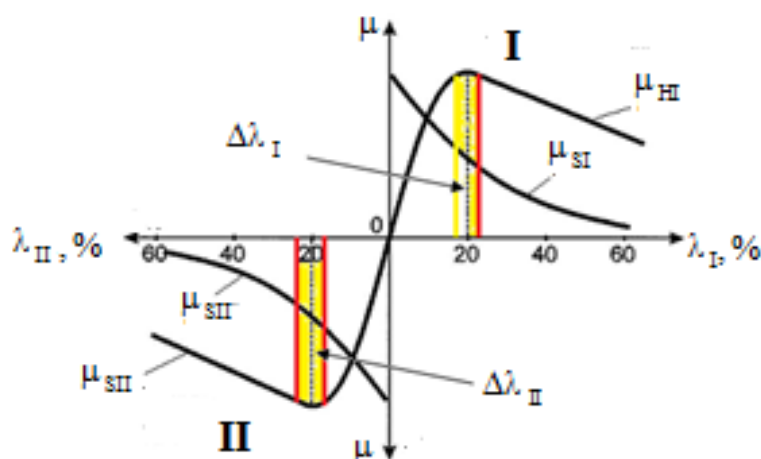


Fig. 1 – The change of adhesion coefficient of wheels depending on the relative partial slip ratio of the wheel contact λ : **I** is the change of the adhesion coefficient μ_I of the vehicle during braking;

II is the change of the adhesion coefficient μ_{II} of the vehicle during acceleration;

μ_H is the adhesion coefficient in the direction of movement of the vehicle;

μ_S is the adhesion coefficient in the direction of movement of the vehicle, λ – is the relative slip of the wheel contact, $\Delta\lambda_I, \Delta\lambda_{II}$ – are the threshold values of the relative slip of the wheel contact when braking and accelerating (control areas)

The relative slip of the wheel contacts λ , when braking and accelerating, is calculated in the information processing unit on the basis of measurements of the angular velocity of the wheel and the speed of the vehicle ω_i, V_i according to the formulas: $\lambda_I = \frac{V - \omega_i \cdot r_i}{V} \cdot 100\%$ – is the relative partial slip ratio of the wheel contact

when braking; $\lambda_{II} = \frac{\omega_{III} \cdot r_i - V_{II}}{V_{II}} \cdot 100\%$ – is the relative partial slip ratio of the wheel

contact when braking, where $r_{i,I,II}, V_{i,I,II}, \omega_{i,I,II}$ – are the dynamic rolling radii of wheels, the vehicle speeds, the angular velocities of wheels. Thus, the algorithms are based on calculation and analysis of the kinematic parameters that are processed in the information processing unit (IPU). When identifying the specified threshold value λ ,

the control of the actuating mechanisms (IM) is performed (Fig. 2). The disadvantages of the existing algorithms are as follows: 1 – insufficient grounds for the choice of threshold values $\Delta\lambda_I = \Delta\lambda_{II} \approx 18 = 20\%$; 2 – complexity of information processing due to the use of kinematic parameters V, ω_i in the algorithms (the speed V is determined approximately); 3 – the adhesion coefficient μ is measured in tenths; this can result in poor accuracy, which reduces the quality of control.

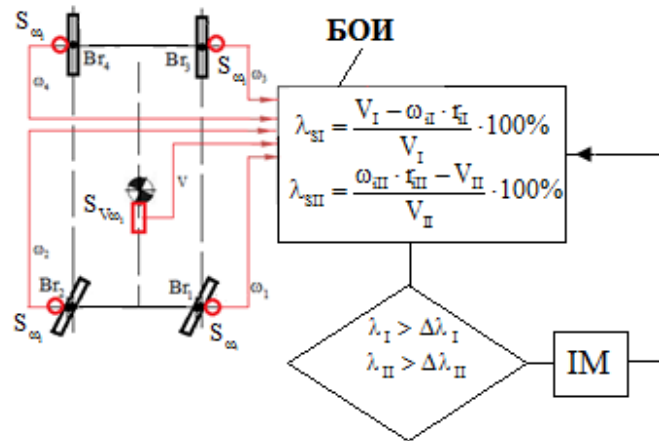


Fig. 2 – The algorithm of modern active safety systems of vehicles

We propose an algorithm based on measuring and analyzing the forces in the contact of the wheels with the road. The algorithm uses information about the lateral forces S_i acting on the wheels (Fig. 3). The control of actuating mechanisms (AM) is performed at negative signs of derivatives of the lateral forces $\frac{dS_i}{dt} < 0$, which means that the slip of the contacts of the vehicle wheels occurs.

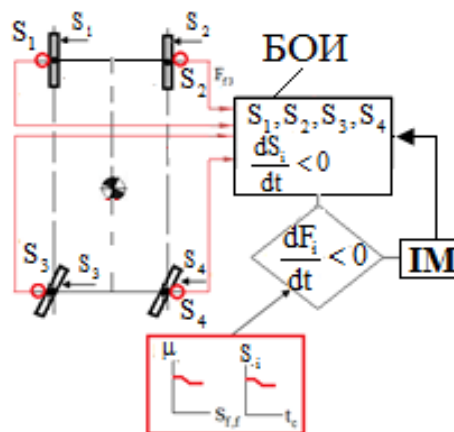


Fig. 3 – ESP Algorithm based on the analysis of forces

The tests have proved the effectiveness of the algorithms for controlling the movement of vehicles based on the analysis of forces.

INTELLECTUAL PROPERTY POLICY: EXPERIENCE OF SEOUL NATIONAL UNIVERSITY

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The national innovation system of the Republic of Belarus is currently in the process of becoming and includes a wide range of elements, among which universities play a special role. The effectiveness of the innovation activity of universities within the National Innovation System is determined by their approaches to the management of intellectual property (IP).

Leading universities in the world have widely used IP policies in their activities. These policies are a solid document that reflects all organizational and legal issues related to the management and use of IP [1, 2]. The application of this approach is supported by the World Intellectual Property Organization.

The relevant policy has the leading Korean university – Seoul National University. According to the QS World University Rankings 2019, Seoul National University ranks 36th in the world, 8 in the region and 1 in Korea [3].

The process of managing IP in Seoul National University is governed by the following basic documents [4]:

- Regulations Governing Intellectual Property Rights;
- Intellectual Property Rights Protection Guidelines;
- Royalty Distribution Guidelines;
- Intellectual Property Management Committee Guidelines.

These documents are based on national legislation and reflect the goals, objectives and procedures of Seoul National University in this area.

The IP policy of Seoul National University addresses the following key issues:

- Purpose;
- Attribution of Intellectual Property;
- Procedure for Deliberation on Invention;
- Securing of Rights to Intellectual Property;
- Maintenance and Abandonment of Intellectual Property Rights;
- Obligations of Inventor;
- Technology Transfer;
- Distribution of Royalty;
- Policy-making organizational structures.

These issues can be clarified and supplemented in various other regulatory documents.

Belarusian universities currently do not have clear IP policies. This limits the ability to commercialize research and development results.

Acquaintance with the experience of Korean universities in this field will contribute to increasing the effectiveness of scientific and innovative activities of universities in Belarus, as well as promote international cooperation.

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THE INFORMATION AND COMMUNICATION TECHNOLOGIES FOR SMALL BUSINESS DEVELOPMENT

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In developed countries small and medium business (SMEs) are the main forms of an efficient economy. They provide a significant part of GDP and a significant part of jobs. However, the Republic of Belarus is still lagging behind the leading economies of the world in terms of its contribution to GDP: organizations of the SMEs form about 25% of GDP (14.9% belong to small business, 6.7% – to medium-sized and 3,1 % to individual entrepreneurs). By 2020, there is a task to increase this share to 40%.

In recent years, Belarus has carried out substantial work to improve the business environment: opening procedures, reduction of small enterprises, tax system's improving etc. Currently, all the necessary doing business institutional and economic conditions, legal framework's liberalization in the sphere of entrepreneurship are being created. Among them there are: the 7th Decree aimed by the President of the Republic of Belarus; «On the development of entrepreneurship» – Republic of Belarus' President Decree No. 9; «On some measures of state support of small business» - Decree of the President of the Republic of Belarus No. 31 «On the State Program of Innovative Development of the Republic of Belarus for 2016–2020»; Presidential Decree No. 8 «On the Digital Economy». All of them contribute to the improvement of our country's position in the global Doing Business ranking. Belarus ranked 37th in 2018 compared to 38th in 2017 (+1) and 44th in 2016 (+7). There have been positive developments in small business support, which can be one of the most important prerequisites for increasing its contribution to GDP and the wide spread of information and communication technologies (ICT). Active competition in the economy stimulates other companies to introduce information technologies to innovate their products, services, business processes and organizational structures.

The contribution of small business to GDP can be strengthened through the use of ICT, which are increasingly involved in the transformation of modern business, providing a fast, reliable and effective change of information. In the new economy, the information capital's role, which includes technological, scientific, technical, socio-economic information, is increasing. The information capital's basis is made up of information technologies that modify the market economy mechanism: the methods of competition are changing, local, regional, national and international information markets and telecommunication goods and services are being formed and nowadays operate on new principles. The use of ICT in SMEs affects the business development strategy, internal processes, the enterprise's structure, personnel policy and overall market behavior.

ICTs provide more and more opportunities for SMEs to participate in a knowledge-based economy, facilitating access and assisting in building a distribution network on a global scale, as well as opening new markets and sources of competitive

advantage. Potential benefits from the use of information technologies for SMEs increase business efficiency, lower costs, and increased productivity. Therefore, in many countries, programs are widely used to attract small businesses to the active introduction of ICT. However, there are many barriers that prevent small businesses from fully realizing the benefits of ICT. Many SMEs themselves may not see their advantages for developing their own business. In many cases, unlike large businesses, they face difficulties in finding the best ways to use ICT elements due to lack of time, information and staff qualification. Often small businesses don't have the human and financial resources for the use of ICT, due to the concentration of their attention on everyday operations, lack of additional resources. On the one hand, they are worried about the costs of creating and maintaining information technologies, and on the other hand, they are uncertain about the expected return on such investments. Often they use of information products for corporate management and communication. Also there are risks associated with the transaction mechanism for contracts concluded using Internet systems. The task of the state is to play a crucial role in overcoming such problems, concentrating on the development of IT infrastructure, broadband access, openness and confidentiality of information, raising the skills of small business workers and developing public-private partnership.

When implementing the Republic of Belarus's development programs, it is necessary to use the experience of other countries, taking into account the unique socio-economic and cultural-historical situation of the country. As for the strategy of more active ICT's introduction in the SME sector, it requires careful, balanced and comprehensive development. To do this, it is necessary to use a systematic approach to this problem's study, based not only on the benefits provided by high technology, but also to identify the obstacles that inhibit their activation.

INFORMATION AND COMMUNICATION TECHNOLOGIES TO IMPROVE POSTGRADUATE MEDICAL EDUCATION

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The current stage of the development of health care in the Republic of Belarus is characterized by the introduction and improvement of information and communication technologies (ICT), providing a single information space

The rapid development of the base of technical equipment of health care organizations with modern medical and diagnostic equipment, expanding the range of their medical support requires a significant increase in the effectiveness of the information support system for doctors.

The system of information and methodological support for all stages and parts of work using innovative educational technologies, including case-technologies (“case-study” situational training techniques), problem-based learning technologies (lecture-discussion, lecture-consultation, etc.), simulation training technologies, etc. is created in Belarusian Medical Academy of Postgraduate Education. The modular distance learning methods are widely used. Website of the Academy contains more than 600 training modules in various medical specialties.

Telemedicine technologies, successfully implemented in the Academy, have shown economic feasibility and clearly demonstrated their viability. Webinars that are conducted by cardiologists, neurologists, dentists, oncologists, pediatricians, therapists, surgeons and other specialists are very popular in all regions of the republic. Due to the new forms of organization of the educational process, the Academy has organized on-line broadcasting of lectures by leading practitioners from various sectors of the national economy, government bodies and health organizations. This allows to ensure the practice-oriented educational process and to improve the efficiency of training managers at all levels of government in the health care system.

Based on the most advanced communication technologies, cooperation with leading Russian and foreign partners in the field of joint educational activities at the postgraduate level is successfully developed. Doctors from Russia, Lithuania, Estonia, Ukraine, Poland, Georgia, Kazakhstan, Uzbekistan and many other countries join online broadcasts of conferences from BelMAPO.

The Academy provided an opportunity for doctors at the local level to improve their qualifications without interrupting their practice, using teleconsultation forms with analysis of specific clinical cases, online seminars, lecture courses, master classes with the participation of the academic staff of the Academy.

The current level of development of educational technologies offers a qualitatively new type of practical training and an objective assessment of the knowledge and skills level in the training of medical personnel – simulation training – realistic modeling of pathological conditions scenarios, medical manipulations, surgical interventions and (or) other clinical situations.

The advantages of simulation training are as follows:

– when mastering practical skills and complex skills, risks to the life and health of the patient are completely excluded;

– trainees have the opportunity to repeatedly develop certain skills, bring them to automatism, develop the best ways to solve the tasks, taking into account professional experience and knowledge;

– teacher is given the opportunity for virtual modeling of an infinite number of clinical situations;

objective control of the quality of care is provided by the results of the training.

The creation of the Republican Simulation Center at BelMAPO, equipped with modern dummies, mannequins and human-like simulator robots will contribute to the implementation of these tasks.

The latest information and communication technologies occupy an increasingly large place in the life of modern man. Their use increases the motivation and cognitive activity of trainees, expands their horizons and allows the use of personality-oriented technology of interactive learning.

They provide high quality presentation of the material and use different communication channels (text, sound, graphic, touch, etc.), allow to individualize the learning process according to the pace and depth of the course. Such a differentiated approach gives a positive result, as creates conditions for the success of each trainee.

INFORMATION AND COMMUNICATION TECHNOLOGIES FOR ORGANIZATION DEVELOPMENT

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The most important condition of the economic growth of organizations and the economy as a whole is the transition to a continuous innovation process, which is impossible without the development of innovative and digital activity of business. In the conditions of a dynamically developing goods and services market, innovation activity is one of the most important components of the success of organizations. The conversion to the digital development path is one of the main factors ensuring its competitiveness.

Today, the competitive advantages of organizations are determined crucially by its ability to rapid introduction and use of information-digital technologies in economic activity. The development of the information society and digital technologies are considered as one of the most important factors for ensuring competitiveness and innovation development in the Republic of Belarus.

Organization development is a natural process of the survival of socioeconomic systems and it is aimed at adapting the system to the new conditions, which are dictated by the market. Organization development is a way of activity of each organization in the digital era. We highlight the main factors that are the driving force for the reorganization and redesign of organizations, i.e. they contribute to the creation of a “new” organization in the conditions of digital transformations.

First, the demographic shifts that led to changes in the staff: a growth of the number of younger and older workers is observed. According to a Deloitte study Generation Y accounts for more than half of the workforce currently. HR managers should take into account that representatives of this generation have high requirements for reward, training and development opportunities, dynamic work and career growth. The globalization of business has caused structural shifts in the labor force, so employers need to focus on assimilation and the common interests of different age groups of staff, which will contribute to the cohesion of staff and teamwork.

Secondly, the use of information and digital technologies in most business processes of the organization is the cause of changes in business models, working conditions and the workflow. So, technologies such as the Internet, artificial intelligence, mobile devices contribute to transformations in the organizational structure of organizations, in the process of production and the services.

At the same time, digital technologies and social networks are creating new approaches to HR processes, such as search, hiring and adaptation of employees, management, staff support, and so on. Organizations, that have chosen an innovative way of development, seek to improve the process of communication with staff, through the introduction of design thinking and the use of behavioral economics, so the process of “digital HR” is carried out actively.

In recent years, organizations of the Republic of Belarus have achieved notable success in creating of information systems and resources. A significant part of the

document has been translated into electronic form. The presentation of state statistical, departmental and tax reporting has been automated. Electronic invoices, an electronic tax collection system, a product labeling system have been introduced. Conditions for electronic interaction between the state and business have been created.

According to the results of a study, which was conducted by the National Statistical Committee of the Republic of Belarus for the development of information and communication technologies and the digital economy, it can be concluded that organizations of the Republic of Belarus are introducing and using digital technologies actively in their business activities. Thus, almost 100% of the organizations of the Republic of Belarus use the Internet to data storage and transmission of information in their activities. More than 80 per cent of organizations use local computer networks. There is a positive trend of the indicator, which characterize the number of organizations-users of the Intranet: the system of information exchange and sharing within the organization. In 2011 this figure was 73.7%, and in 2017 – more than 82%. The per cent of organizations of Belarus using Extranet system is not high, it is only 9.3% in 2017. However, it is also possible to observe the growth trend of this indicator, thus it can be concluded that more and more organizations are striving to introduce and use information systems and the network not only for internal corporate purposes, but also for the exchange of corporate information with a business partner.

Thirdly, the growth rate has increased. The innovative solutions, which is implemented quickly, force organizations to respond quickly to transformations and change their market strategies in order to adapt to the new conditions of the national and international markets.

Digital technologies contribute to the fact that organizations should make transformations in all areas of their business activities to respond to the requirements of the modern market in a timely manner and ensure the competitiveness of products and services.

Fourth is the ensuring digital and information security organization. The digital transformation process has also a negative impact on the organization's activities. Recently, there has been a growth of crimes, which is related to the unauthorized access to organizations' computer data, corporate networks and databases, electronic accounts, and so on. Therefore, the protection of commercial information is necessary for the safe activities of the enterprise, its workflow in order to preserve commercial secrets. So managers should develop and implement software and hardware solutions to ensure digital and information.

To summarize, it can be noted that there are the continuous development of information and communication technologies, the rapid expansion of the digital potential of organizations, the increasing of the role of the production of information digital products and services. These trends make it necessary to the reorganization of the business processes of organizations and lead to the transformation of organization itself. In turn, the transformation process to a new development path requires development and implement a digital strategy. The goal of this strategy is reforming of all business processes and increase of the efficiency of the organization's activities by developing its innovative potential and digital activity.

E-PORTFOLIO AS A TOOL FOR ORGANIZATION OF LIFE-LONG LEARNING

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Life-long learning is not just a trend in the modern society, it is a great vital necessity in the society where a lot of professions appear and disappear every year. It becomes crucial for any specialist to arrange appropriate learning through the life and to show diplomas, certificates and other evidences of the gained skills and knowledge. E-portfolio is usually used as a complex resume with all achievements but it also is able to support succession and flexibility during the organization of life-long learning.

A lot of educational institutions offer their students platforms with templates to create their e-portfolios. These e-portfolios provide information about curriculum, timetable, and campus life. Here professors can give tasks and tests and then check them. But for future professional life the most valuable part of the e-portfolio is assessments [1, 2, 4] as they can allow to be qualified as a specialist in some field. Each new educational institute will offer to create an e-portfolio and the succession in learning can be lost. While arranging self-education it is good to register all the achievements on an independent platform, that means to create own e-portfolio.

Centralized educational system of the Republic of Belarus has facilities for creating a platform for e-portfolios thus they can become education and work online registers. The authenticity of the provided data may be secured by electronic signatures by educational institutions, employers and qualification commissions. The e-portfolios of this type give the opportunity to optimize the learning management system as they can track the whole educational process: all studied subjects, all courses and self-learning (qualification in this case can be proved by a chief or a qualification commission). Thorough registration let learners and educational institutions create individual learning plans and provide succession of learning, and employers will get the opportunity to find specialists with definite set of skills.

When timing the learning process the flexibility of education is of great importance. Busy life can dictate the necessity to gain new knowledge and skills by different means, like distant courses, self-learning, evening classes and so on. Individual learning plan (ILP) is often seen like flexibility, but ILP is normally arranged to study within one educational institution during some agreed period of time [3, 4]. Flexibility of educational system means that a person chooses educational institutions, targeted courses, master-classes and appropriate time and place for these activities. Educational institutions will be able to offer corresponded classes to potential students using hashtags with specified interests in e-portfolios. It will widen the choice of classes and courses and will let the students build their own educational routs in accordance to the changing demand of the labour markets.

It is obvious that educational institutions will enjoy close relations with potential students as it allows to enrich their educational activities, to adjust their curriculums to the demand and so to become more competitive in the market.

The information society needs new approaches and tools in all spheres of national economy and private life. E-portfolio as a register for work and educational experience can help to organize appropriate life-long learning and if necessary smoother transitions from one profession to another.

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CASSETTE ROBOTIZED URBAN TRANSPORT SYSTEM OF MASS CONVEYING PASSENGER BASED ON THE UNMANNED ELECTRIC CARS

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Short project description. We suggest automated public urban transport system capable of operating in the streets with heavy traffic uninterrupted by other vehicles and of transporting a number of passengers comparable to the subway. The system operates without any control by man and it is a fundamentally new form of public transport based on the electric mobile autonomous electric cars (unmanned). Technical and economic characteristics provided by this transportation system, are not available at the currently used vehicles of urban passenger transportation, such as bus, trolleybus, tram and metro. All the unmanned electric vehicles are linked to a control circuit. The system is adaptive to passenger traffic that is works on a service request for transportation with a minimum response time to a request (passenger's waiting time). It combines the features of personal (short waiting transport time and non-stop or with a minimum number of stops, travel of passenger from point of origin to destination) and public transport (high capacity).

The system comprises. Cassette robotized urban transport system of mass conveying passenger transportation system includes separate narrow path (rail or monorail) which borders upon the sidewalk and is fenced from it to the right and fenced from the roadway to the left; stopping points of embarkation and disembarkation of passengers, equipped with turnstiles; unmanned autonomous electric cars with a capacity of 50 passengers (Figure 1).

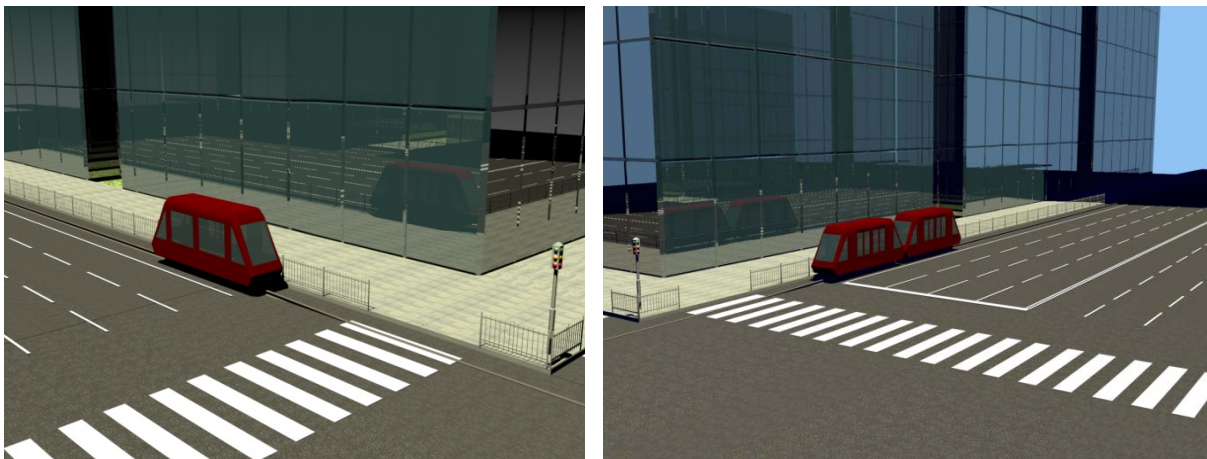


Fig. 1 – Autotrain from one or two electric vehicles at an intersection

Electric cars are based in the assembly points 1 and 2 located in the final destinations (Figure 2). The recharging of the electric cars is performed there and from there they move forward to the route.

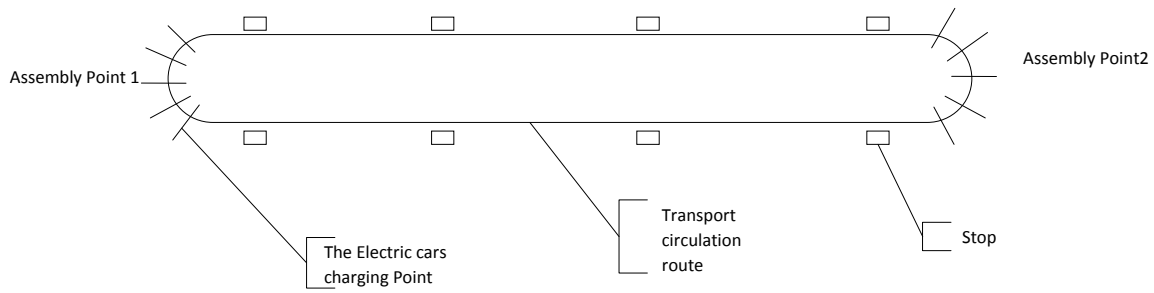


Fig. 2 – Basing structure and the transport circulation route

The system operates. Cassette robotized urban transport system of mass conveying passenger transportation system in its initial state is in "sleep" mode and is activated at the time the passengers come to the station (stop). Passing through the turnstile the passengers pay the travel fee and at the same time indicate their destination station. This information is submitted to the system server, where the mobility plan for this stop is formed. Based on the data from all stops the mobility plan M of the trips of passengers is built up:

$$M = \begin{pmatrix} 0 & m_{1,2} & m_{1,3} & \dots & \dots & m_{1,j} & \dots & m_{1,k} \\ 0 & 0 & m_{2,3} & \dots & \dots & m_{2,j} & \dots & m_{2,k} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & \dots & 0 & m_{i,i+1} & \dots & m_{i,j} & \dots & m_{i,k} \\ \dots & \dots & \dots & \dots & \dots & \dots & \dots & \dots \\ 0 & \dots & \dots & \dots & \dots & \dots & 0 & m_{k-1,k} \\ 0 & \dots & \dots & \dots & \dots & \dots & \dots & 0 \end{pmatrix} \quad (1)$$

Where: k – number of stops, $m_{i,j}$ – number of passengers, who get in at the i stop in order to get to the j stop ($i, j = 1, \dots, k$). All the elements on the main diagonal of the matrix M and under its main diagonal are equal to zero (because the passenger can neither light down on the same bus stop where he got in the car nor go "backwards"). Thus, all the passengers, who are at the stations are differentiated in accordance with their final trip points. The server processes the mobility plan using special software and sends to the route the number of electric cars necessary to cover the passenger traffic at the current time. And the electric car riven up to the i -th stop has an electronic label (on the trunk display) indicating the destination station (2 stations). Thus, passenger travel is ensured with a minimal number of stops (in this case just one).

This is called cassette transport because the electric cars are collected in virtual cassettes from one and up to six electric cars that form a road train. It uses the well-known autocaravaning principle founded by the European Commission in September 2009 in the project Safe Road Trains for the Environment (SARTRE), which allows several machines moving on the road in an organized column. Column moves in

synchronism with traffic light signals it obtains from the system server. As a result, a non-stop auto train movement is organized.

The title indicates conveyor transport mode, which means that the motion process of the cassettes (auto trains) is continuous with a minimum interval of 20 seconds in between. This also is the minimum sufficient time for passengers loading. For this purpose, the electric cars are narrow (their width is one meter) and with many doors. Conveyor movement method enables maximizing the use of precious road space and evenly distributing the load on the roadway and provides passenger transport timeout from 20 seconds to one minute at any time of day. Of particular note is that this is the only kind of urban public transport ready to serve 24 hours a day.

THE USAGE OF R&D STATE REGISTER FOR THE PURPOSES OF TECHNOLOGICAL FORECASTING

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Organization can implement new product's technical preparation yourself or by the means of R&D state register. The second way reduces the cost and time involved. However, there is a need to develop a R&D with certain characteristics ranking methodology.

According to the methodology, the assessment should be based on the following criteria: the research direction's prospects; the new technology's potential within the chosen direction; R&D's performers specialization. The proposed methods for promising R & D selection with the aim of a new product development: a) target requirements' analysis and assessment as well as the formation of R&D data subset from the state register according to the identified target requirements; b) a set of innovative projects' evaluation indicators calculation; c) selected target groups' key elements edification which obtain the largest amount of innovative potential and activity; d) innovation process' key objects selection; e) definition of connections between key objects.

A) Target requirements' analysis and assessment as well as the formation of R&D data subset from the state register according to the identified target requirements. The information array of R&D data from the state register data based on classified characteristics is formed. The methodology provides for an assessment based on the following criteria: significance, intensity and frequency of mention. The criteria for significance is a scientific direction's elaboration level. The intensity assessment will be investigated within the framework of the previously defined direction, namely, determined by the number of scientific works in a certain direction. A frequency mentioning factors analysis in the total population clearly shows the intensity of the efforts within the chosen direction of scientific activity.

B) A set of innovative projects' evaluation indicators calculation. To assess innovation development in the framework of the target group identified at the previous stage, we may use the concepts of innovation activity (IA), innovation potential (PI) and a composite indicator of the prospects for innovation development (SPID):

$$SPID = \sqrt{IA \cdot PI}$$

IA is defined as the proportion of R&D within the selected grouping feature, in the total number of R&D performed for a certain sample: $IA = \frac{Q_i}{Q}$, where Q_i is the number of R&D selected from a certain sample by a certain criterion i ; Q is the total number of R&D in some sample.

IP is defined as the R&D share within the selected feature of the grouping in the total gross volume of R&D in value terms: $PI = \frac{F_i}{F}$, where F_i is gross turnover of R&D in value terms, selected from a sample by a certain criterion i ; F is the total gross turnover of NIOC (T)P of a certain sample in value terms.

C) Selected target groups' key elements edification which obtain the largest amount of innovative potential and activity. The IA value allows to judge whether the innovations correspond to a certain stage of innovative development (a specific R&D or their combination selected by a certain criterion, for example, by region or priority direction of scientific and technical activity, etc.), and IP characterizes the state of this stage. We single out the following stages of innovation development: the birth, formation, development, and stagnation. Moreover, each of these stages exists in one of the following states: onset, intensive development, rich development, fading development. Grouping involves identifying the range (R) of the intensity of the trait:

$$R = X_{\max} - X_{\min}$$

where X_{\max} – the maximum value of the trait intensity; X_{\min} – the minimum value of the trait intensity. Next, you need to determine the length of the grouping interval (h): $h=R/n$, where n is the groups number into which the population is to be divided. Conventionally, we assume that the distribution will be linear. Since the maximum possible value of PI and IA is 1 (100%), and the minimum is 0%, the span will be equal to 100%. When grouping the above indicators into four groups, the interval will be equal to 25%. The R&D group with a high IP has prerequisites for moving to the next, higher stage of innovative development. A group with a low PI may be at a previous stage of development, since a low PI shows a slowdown in development.

D) Innovation process' key objects selection. On the basis of the samples obtained and the calculations made, an assessment of the prospects for innovation is made. At the same time, it is obvious that (with the equality of other parameters), the results of R&D, which do not require modification for their practical use, should be in the greatest demand. On this basis, it can be argued that R&D, brought to the stage of possible use in mass production, will have greater attractiveness for investors.

E) Definition of connections between key objects. In the process of research, a mechanism was developed to regulate the interaction between participants in promising industries in the form of technological platforms. It contains organizational and legal measures for the R & D commercialization. An exceptional feature of the developed mechanism is the consideration of risks and vulnerabilities associated with the introduction of R & D results into civilian circulation, and due to the requirements of the legislation and the practice of its application. The above-described method allows you to create evaluation criteria that will improve the economic methods of managing new product.

The application of this method will allow to optimize work with the R&D state register and to assess the prospects of using their results for the purpose of innovative development.

THE METHODS AGGREGATED ASSESSMENT OF DIGITAL TRANSFORMATION MANUFACTURING INDUSTRIAL EFFECTIVENESS REPUBLIC OF BELARUS IN A GLOBALIZING WORLD ECONOMY

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In a globalizing world economy, there is need for integrated assessment of the digital transformation manufacturing industry effectiveness to Republic of Belarus. The aggregated assessment methods for digital transformation of industry effectiveness is due to social significance and takes into account the socio-economic and financial components of performance with the participation in the digital transformation of industrial enterprises various forms of ownership. This assessment will expand the possibility of alternative economically sound solutions at different levels organizational and economic digital transformation mechanism manufacturing industry Republic of Belarus.

Thus, the methods aggregated assessment of digital transformation manufacturing industry effectiveness Republic of Belarus there are base on following principles:

- the long-term cyclical monitoring. The results of digital transformation manufacturing industry should be controlled, beginning at the evaluation project efficiency of digital transformation of manufacturing industry on stages digital industrial modules development and their implementations to industrial activity manufacturing industry enterprises, up to by issue, sales and services of high-technology and high technology industrial output;

- the use of time lags and estimated effects of digital transformation industry on the economic result of the organizational-economic mechanism development digital transformation manufacturing industry Republic of Belarus in the time intervals;

- the discounting and impact inflation (reduction of currencies used in the process digital transformation manufacturing industry to a single currency, deflation by the base inflation index corresponding to this currency);

- the possibility comparability results without the introduction in production processes of digital industrial modules and with their implementation;

- the forecasting risk and various kinds of adverse significant prevention consequences in the process digital transformation manufacturing industry (in quantitative form in the discount rate);

- the influence of circulating funds volume, needed for digital transformation manufacturing industry.

In addition, the aggregated assessment methods of the digital transformation of the manufacturing industry effectiveness to the Republic of Belarus contain a social and industrial assessment of the impact of digital transformation of the manufacturing industry on the population and related sectors of the economy:

- the change in the value of citizens' property due to the development digital transformation of the manufacturing industry;
- the decrease in the level of retail prices for certain goods and services due to the increase in the supply of these goods in the development process digital transformation of industrial production;
- the impact of the digital transformation manufacturing industry on the health of industrial workers, including the environment and public health;
- the influence of digital transformation manufacturing industry on production volumes (works, services) of related industries;
- the significant saving of resources due to the use of high-tech industrial products integrated into broadband Internet networks using high-speed processing of large amounts data and other technical and technological means of the fourth industrial revolution.

To assess the effectiveness of the digital transformation manufacturing industry Republic of Belarus, can be identified five parametric groups, such as: economic, social, technical and technological, environmental, resource and raw materials. Each parametric group contains quantitative indicators, formulas for their calculation, are units of measurement.

The selection of indicators produced, based on the analysis of existing methods assessing the effectiveness of innovative projects, available statistical data of the National Statistical Committee of the Republic of Belarus, as well as indicators of the UN sustainable development goals.

Thus, the proposed methods aggregate assessment of the digital transformation effectiveness can be use in the complex diagnostics and evaluation of the results digital transformation industrial enterprises, industrial associations, sectors of the economy and the national economy as a whole. There are can also become the basis for management decisions, the development an alternative integrated methodology for assessing the effectiveness investment projects taking into account the diverse quantitative and qualitative effects.

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