

ANTIBACTERIAL AGENT FOR TREATING INFECTIOUS DISEASES OF BACTERIAL ORIGIN

Pertinent art

The invention relates to medicine, namely pharmaceuticals, and may be used for treating diseases of bacterial origin, especially in treating diseases caused by drug-resistant strains of microbes, and bacterial and viral (mixed) infections.

Prior knowledge

Main methods and means to damage pathogenic bacteria in the present are antibiotics which combine all medications that suppress activity of infectious agents such as bacteria, fungi, and protozoa.

However, due to increased drug resistance of infectious agents to the known groups of antibiotics, the problem of development of new antimicrobial drugs has not lost its relevance.

Thus, for example, worldwide there is an increase in tuberculosis incidence rate and increase in mortality observed, caused by drug-resistant pathogens. Resistance to antituberculosis drugs was found in all 35 surveyed countries and regions, indicating that the problem is global.

Polyresistance to antituberculosis drugs is the most difficult form of drug-resistance, known at present. According to WHO, since the early 90-ies in different regions of the planet several outbreaks of multidrug-resistant tuberculosis have been reported.

It is known that molecular iodine can easily pass through bi-lipid cell membranes of microorganisms and penetrate into a cell. Antimicrobial action of iodine compound is due to the ability of iodine (elemental iodine, hypoiodine acid, iodine cation) to interact with NH_2 -groups of amino acids (lysine, histidine, arginine, etc.), as well as nucleotides (adenine, cytosine, guanine) forming N-iodine derivatives. In addition, there is an oxidation of SH-groups of cysteine

taking place, resulting in disruption of protein synthesis. Interaction with phenolic groups of iodine tyrosine leads to breaking of hydrogen bonds in these amino acids. Affecting double carbon bonds of unsaturated fatty acids, iodine thereby changes the properties of lipids.

The ability of iodine to easily penetrate through cell membranes makes its application more valuable for those infections, the main development of which takes place in intracellular structures (brucellosis, clamidiosis, hepatitis, etc.).

There is a known drug *Yodomidol*, with bactericidal and virucidal activity, containing iodine, potassium or sodium iodide, synthetic water-soluble polymer, natural polymers such as polysaccharides and mono- and oligosaccharides, in the following ratio, g/L:

iodine	6-10
potassium iodide	9-15
synthetic water-soluble polymer	2-4
natural polymer (polysaccharides) and mono- and oligosaccharides	8-120
water	Balance

(KZ 6730B, 16.11.1998).

Disadvantage of this drug is its relatively high toxicity.

There is a known virulicidal pharmaceutical product (EP 0978289 A1, 02.09.2000), with antiviral activity, which contains iodine, potassium or sodium iodide, synthetic water-soluble polymer, a mixture of natural mono-, oligo- and polysaccharides and lithium chloride with the following components ratio, g/L:

iodine	0,8 – 25
potassium iodide	1,2 – 38
lithium chloride	0,1 – 20
synthetic water-soluble polymer	0,01 – 6
mono-, oligo- and polysaccharides	8– 400
water	Balance

There is a known bactericidal and virucidal pharmaceutical product for

prevention and treatment of mono- and mixed infections, including tuberculosis, brucellosis, plague, hepatitis, HIV, containing a pool of proteins and/or halogenated proteins, carbohydrates and/or halogen-derivative carbohydrates, synthetic water-soluble polymer, lithium chloride, potassium or sodium iodide, iodine, water or saline solution in the following ratio (g/L):

pool of proteins and/or halogenated proteins	From 0.01 to 200
carbohydrates and/or halogen-derivative carbohydrates	From 0.01 to 450
synthetic water-soluble polymer	From 0.01 to 100
lithium chloride	From 0.01 to 200
potassium or sodium iodide	From 0.01 to 300
iodine	From 0.01 to 200
water or saline solution	to 1 L

(KZ 15116A, 15.12.2004).

Bactericidal and virucidal pharmaceutical agent represents a complex physical-chemical system, formed by mono- and polyfunctional ligands (anions, proteins, carbohydrates, synthetic water-soluble polymers) and acids (iodine, alkali metal cations), which is in pseudo-equilibrium state. In this system, there are adjoint complexation, association and dissociation processes taking place. A sequence of processes of acid-base interactions; chemical nature of the polyfunctional ligands (proteins, carbohydrates, water-soluble synthetic polymers) involved in them, the presence in the process of ligands with different molecular weight (e.g. mono-, oligo- and polysaccharides) results in structure formation in the system, and thus it acquires all properties of a colloidal system.

The presence of pharmaceutical iodine in the composition not only enhances bactericidal and virucidal properties due to those of iodine itself, but it also ensures

a synergistic effect of each active substance individually and of all of them together present in the agent in balanced concentrations.

This product contains halogen derivative compounds: halogenated proteins and halogenated carbohydrates.

There is a known iodine complex of alkylpolyglycosides (WO 9639839 A1, 19.12.1996) containing (in % wt.) from 0,5 to 30 of iodine; from 0,2 to 14 of iodide in the form of salt; acids or their blends, and from 2 to 85 of sugar surfactant selected from the group of sugars containing alkyl glucose ether, aldobionamide, glycinamide, glyceramide, glyceroglulipoid, fatty polyhydroxy acids amides, alkylpolyglucocides with general formula $R_1O(R_2O)_b(Z)_a$, where R_1 - monovalent organic radical of from 6 to 30 carbon atoms; R_2 - divalent alkylene radical having from 2 to 4 carbon atoms; Z - sugar derivative containing 5 or 6 carbon atoms; b – natural number from 0 to 12, and a – natural number from 1 to 6.

There is a known method for producing immobilized enzymes through complexation reaction with molecular iodine and potassium iodide (RU 2157405 C2); as a result of complexation reaction, proteins are produced that contain bound iodine, and which from a solution pass to a solid phase state, i.e. water-insoluble complexes are formed. Solid phase state is characterized by the formation of polydisperse particles ranging in size from several micrometers to tens or hundreds of microns, which (the particles), in view of the large total surface area of zymophore able to interact with molecules of microbial substrates, ensure antimicrobial action of immobilized enzymes. Iodine that is a part of the complex provides a microbicide effect.

There is a known drug for administration of antiseptic agents, including halogen, into lower respiratory tract, containing at least one antiseptic in combination with support in the form of particles, obtained by known methods, and the carrier contains at least one liposomal preparation, microspheres sample, nanoparticles preparation, large porous particles preparation or molecules preparation, coated with polymer using a pulsating laser ranging in size from 1 to 30 microns (Patent RU 2212884 C2).

In all of the above known patents, authors did not set the task of synthesizing complex compounds with a given structure and properties, or excreting complex compounds from solutions and determining their composition and physical-chemical properties, which makes it hard to use complex iodine compounds with carbohydrates and proteins with biocidal properties as medicinal products. Moreover, the development of appropriate dosage forms, without a specific set of properties and qualities of complex iodine compounds - antibacterial agents, characterized by physical and chemical properties and composition, is hindered.

In recent years, some works devoted to exploration of the structure of complex compounds of carbohydrates with salts of magnesium, calcium and other complexing agents have appeared in scientific literature (*O.Nimz, K.Geßler, I.Uson, W.Saenger // Carbohydrate Research 2001. V. 336. P.141–153.; M.Noltemeyer, W. Saenger // JACS 1980.V.102:8.9.P.2710.; M.Noltemeyer, W. Saenger // Nature.1976.V.259. 26.P.629*).

Crystalline structure of a whole number of enzymes with having in its composition ions of magnesium, potassium, calcium, lithium, in their composition, i.e., metal salts, has been established. (*Y.Goldgur, F.Dyda, A.B.Hickman, T.M.Jenkins, R.Craigie, D.R.Davies // Proc.Natl.Acid.Sci USA 1998. V.95. №16. P.9150-9154.; F.Dyda, A.B.Hickman, T.M.Jenkins, A. Engelman, R.Craigie, D.R.Davies // Science. 1994. V.266. P.1981-1986*).

At the same time there are no works involving a purposeful synthesis of iodine coordination compounds with a tailored nanoscale structure and, accordingly, tailored biocidal properties, suitable for implementation of a mechanism of action of these compounds.

Thus, the techniques disclosed herein may create antibacterial agent (hereinafter ABA) for the treatment of diseases of bacterial origin, including hospital acquired diseases and drug resistant tuberculosis (hereinafter TB).

Additional techniques disclosed herein may develop a method for preparation of antibacterial agent and ABA-based drug to treat infectious diseases

of bacterial origin.

The technical result of the disclosure is the increase ABA efficiency *in vivo* through activation of immunocompetent cells.

Summary

The technical result is accomplished through the developed ABA, which represents an ionic nanostructured complex (INSC), formed by proteins and/or carbohydrates, metal salts and iodine intercalated into them, while to obtain an ordered structure of antimicrobial agent and the necessary immunotropic action, the complexation reaction is conducted in four stages – first is interaction of carbohydrates and proteins with metal salts; second step is intercalation of 5-95% of the required amount of iodine into a complex formed during the first stage of complexation reaction at a certain ionic strength; third stage is introduction in the complexing reaction of proteins containing at least one chain-terminal amino acid with electron-donating functional groups and a specific site, accounting for a required immune response, and the fourth stage is intercalation of the remaining amount of iodine in antibacterial agent.

In addition, an ABA was proposed, which, despite the fact that it has a weak anti-tumor activity, a weak radioprotective effect, however, in conjunction with the unique ability to recover hematopoietic function of bone marrow, could be of great practical importance for the prevention of possible adverse effects of chemo- and radiotherapy in **accompanying** complex drug therapy of tumors.

Another technical result is accomplished by the fact that proteins and/or polypeptides that are part of the ABA, have immunogenic activity and contain at least one terminal amino acid with electron-donating functional groups, which –

when ABA is administered into body, anchor in the area of stimulating and costimulating receptors of immunocompetent cell through chain-terminal amino acids possessing hydrophobic and electron-donor functional groups, and specific sites of these proteins activate immunocompetent cells of the first and the second lines of defense - monocytes-macrophages and cytotoxic T-lymphocytes.

Further, the disclosure includes a pharmaceutical form of the claimed ABA.

Depending on the specific proposed application, the pharmaceutical composition may be prepared in the form of a solution, suspension, parenteral composition, ointment, cream, aerosol, powder, tablets, capsules, or other acceptable dosage form, which are administered in certain doses, applied or mixed appropriately. Pharmaceutical formulations may include:

a) potential formulations - filler, in particular, pyrogen-free water, buffer or normal saline solution;

b) ointments, creams, aerosols - media, in particular vegetable or synthetic oil, lanolin, petrolatum, or high-molecular alcohols;

c) tablets or capsules - thinners, in particular lactose, binders, lubricating substances (e.g., stearic acid), as well as decomposition products (e.g., corn starch).

All pharmaceutical formulations may be combined with antibacterial (e.g., antibiotics), antiviral, antitumor, immunomodulatory and other agents if, when combined, they provide a synergistic effect with the claimed pharmaceutical compositions, or are indifferent toward them, but in combination they expand a therapeutic spectrum.

Moreover, ABA may be used as a non-medicated agent (BAA, food additive, feed additive, personal care product component such as lotions, toothpaste, chewing gum, etc.) subject to observance of certain conditions. Such conditions include, for example, the use in compositions of those components only and only in the concentrations specified in the Codex Alimentarius.

Non-medicinal preparations based on a complex compound of the present

disclosure have immunomodulatory effects and may be used for the prevention of infectious diseases, such as seasonal influenza, ARVI, iodine deficiency, as well as an adaptogen.

This disclosure is based on a surprising fact that in solutions of salts of alkali and alkaline earth metals, at a certain ionic strength in the presence of carbohydrate and / or protein, the complex is released into a solid phase in the process of iodine intercalation.

Another surprising fact, as is established by experimental data, is that the present techniques enable to introduce proteins in the antimicrobial agent composition that contain sites with specific immunological function.

LIST of Drawing Figures

The invention is described, by way of example only, and illustrated by the following drawing figures.

Fig. 1-4 represents micrographs of different crystal structures for the preparation FS-1.

Fig. 5 shows the dependence of the yield for calcium complex of triiodide-ion with carbohydrate on the ionic strength.

Fig. 6 shows the dependence of the yield for the magnesium complex of triiodide ion with carbohydrates on the ionic strength.

Fig. 7 shows the formation of stable coordination compounds in the system carbohydrate-protein-salts LiCl, MgCl₂.

Fig. 8 shows the structures illustrating the interaction of molecular iodine with lithium halides, carbohydrates, and side amino acid residues of the protein.

Fig. 9 represents a diagram of the ABA subunit formation.

Fig. 10 a-i represents micrographs of the compounds by examples 1-9.

Fig. 11 represents a micrograph of the compound by Example 5 (FS-1).

Fig. 12 demonstrates the dynamics of survival of rats in the control and experimental groups during 30 days after irradiation: 1) at irradiation dose of 800 R; 2) at irradiation dose of 800 R against the HRP oral administration (1.0 ml) 30

minutes before irradiation.

Data, supporting the possibility of realization

Proceeding from the above, a method for preparation, in order to ensure the preservation of properties of immunogenic proteins in the antibacterial agent composition, is supplemented with the third and fourth stages of complex formation.

In the context of the present techniques, the components, their interrelationship, and the ionic strength interval may be significant features in the ABA synthesis.

Every attribute that determines the ABA composition and structure, is necessary and sufficient to achieve the formulated goal. None of them can be excluded or replaced with another, otherwise the technical result will not be obtained. Selection of both the qualitative composition of substances that form ABA, and quantitative ratios of components, and the ionic strength interval, was based on regularities of complex formation and numerous experimental data on the determination of ABA antibacterial activity, depending on the composition of its constituent components.

The qualitative composition of substances was chosen on the basis of their biological significance and chemical properties that provide an antibacterial effect.

Carbohydrates, selected by the authors of the present disclosure as ligands, are an extremely important class of natural compounds. In biology and medicine, the value of carbohydrates consists in the dominant role assigned to them in animal organisms, and the complexity of their functions. Carbohydrates are involved in most biochemical processes in the form of high-molecular particles, although many biologic fluids contain mono- and oligosaccharides (Comprehensive Organic Chemistry / Edited by E. Haslam. V. 5. Biological Compounds Pergamon Press, 19).

The main feature of the ABA, which represents a complex compound of iodine

with carbohydrates and/or proteins and metal salts, is the presence of proteins with a specific set of electron-donating functional groups in terminal amino acids and sites.

Proteins play a key role in almost all biological processes; determine the course of biological reactions in cells and are involved in a variety of other functions - such as transport of substances and their accumulation.

The present disclosure also includes low-molecular peptides and their constituent monomers.

Transport role of proteins is extremely important, because a diffusing molecule bound with protein, in case of passing through the membrane, is not chemically modified and does not link with other types of molecules. Mediated, or simplified, membrane transport processes are characterized by saturation kinetics (i.e. the transport system may be saturated by the transported solute) and specificity to transported substance.

The possibility of mediated transport is due to proteins that may reversibly bind specific substrates, including iodine molecule. These transporting protein molecules have different names: transport systems, transporters, carriers, or translocases.

Table 1 shows the ABA compositions, synthesized from carbohydrates, proteins, and iodine at different ionic strengths of the solution created by the salts of alkali and alkaline earth metals. The crystalline structure of some compounds (antibacterial agent), depending on the ratio of carbohydrate: protein (polypeptide), is shown on optical and electronic photographs, fig. 1-4.

As can be seen in the photographs, ABA may form nanocrystals (Fig. 1: 1A with 400x enlargement, 1B with 40000x enlargement), microcrystals (Fig. 2: 2A with 5000x enlargement, 2B with 12000x enlargement) that are rather large (0.1 mm), monocrystals (Fig. 3), or crystals of various sizes (Fig. 4).

The size of crystals decreases with increasing content of carbohydrate relative to protein (polypeptide), all other things being equal (ionic strength of the solution), as well as with increasing the ratio of iodine: carbohydrate, and/or

protein (peptide).

The reaction of ABA synthesis, according to the method claimed, proceeds consistently by complexation reactions. At the first stage, a formation of complexes between carbohydrates (L_1), protein (L_2), polymers (L_3), and salts containing calcium and magnesium cations, takes place.



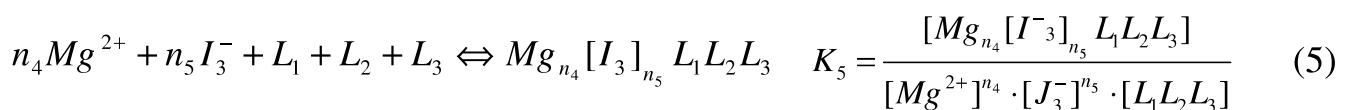
In the solution, prepared for iodine intercalation, the complexation of iodine and potassium iodide takes place:



There is an intercalation of iodine and/or polyiodide ion taking place in compounding of the above solutions, i.e. interaction between the complex particles formed both in the first solution and in the second one. In this process a redistribution of substances that make up ABA (complex) according to their donor-acceptor properties, occurs.



Triiodide ion produced as a result of reaction (3) is also a strong complexing agent, just as a molecular iodine.



$$n_6Ca^{2+} + n_7I_3^- + L_1 + L_2 + L_3 \rightleftharpoons Ca_{n_6}[I_3]_{n_7}L_1L_2L_3 \quad K_{10} = \frac{[Ca_{n_4}[I_3]_{n_7}L_1L_2L_3]}{[Ca^{2+}]^{n_6} \cdot [I_3^-]^{n_7} \cdot [L_1L_2L_3]} \quad (6)$$

ABA output:

$$[Mg_{n_4}^{2+}I_3^-L_1L_2L_3] = \frac{K_5[L_1L_2L_3Mg_{n_1}^{2+}] \cdot [KI_3]^{4n_3}}{[K]^{5n_4}} \quad (7)$$

$$[Ca_{n_4}^{2+}I_3^-L_1L_2L_3] = \frac{K_6[L_1L_2L_3Ca_{n_5}] \cdot [KI_3]^{5n_4}}{[K]^{6n_5}} \quad (8)$$

The final product output depends on physico-chemical parameters of the reaction (Table 2, 3).

The unexpected fact was that at a certain ionic strength of the reaction medium, the ABA output approaches 100%.

According to results of calculation of assumed equilibrium, the ABA output changes (increases) with the increase in ionic strength (Fig. 5, 6). There is an especially significant effect of ionic strength observed for the complex containing magnesium ions (Fig.6), which may be due to characteristics of this ion as a harder acid according to Pearson [Pearson R.G., Journal ACS, 1963, 85, cl. 3533. Pearson R.G. Journal Chemical Education, 1968, 45, cl. 643. Pearson R.G., Chemical Communication, 1968, cl. 65, Gehlen H.Z., Physical chemistry, 1954, 203, 125. Finston H.Z., Rychtman A.C., A new view of current acid-base series. N.Y., Wile, 1982].

Even more surprising was the fact of ABA crystals formation, which represents an ionic polymer complex, in the process of extraction using the method of centrifugal chromatography and / or drying; at that the composition of monocrystals is well-defined and constant, which indicates the formation of an individual ABA compound. The ABA structure and sequence of actions for this structure formation, according to the method for antibacterial agent preparation, can be represented as follows (Fig. 7). In this figure, blue balls are carbon atoms, dark blue - nitrogen atoms, yellow - chlorine atoms, red - oxygen atoms, black - magnesium atoms, brown - lithium atoms. For the

structure I $\Delta E = -106,01$ kcal / mol; for the structure II $\Delta E = -79.12$ kcal/ mol, and for the structure III $\Delta E = -88,86$ kcal / mol.

Formation of complex polyionic compounds in the carbohydrate-protein-salt system of alkali or alkaline earth metal is confirmed through quantum-chemical calculations and UV, Fourier-transform IR spectroscopy, electron and optical microscopy, quantum-chemical calculations data.

Within the framework of initio quantum-chemical 3-21G ** method, calculation of I-III structures was performed (Fig. 7). In calculations the carbohydrate was simulated with ethanol, protein skeleton – with amide, and one of the most donor-active acid residues, histidine, - with imidazol. ΔE complexation energy was calculated as follows:

$$\Delta E = E(\text{compl}) - (E(\text{LiCl}) + E(\text{ethanol}) + E(\text{amid or imidazol}))$$

For the structure I $\Delta E = -106,01$ kcal / mol; for the structure II $\Delta E = -79,12$ kcal / mol; for the structure III $\Delta E = -88,86$ kcal / mol. Calculations have shown that coordination of salts LiCl, MgCl₂ with donor-active groups of protein and carbohydrate is energetically favorable.

In intercalation of molecular iodine into the system, the complexes IV-VII are formed, in which molecular iodine is coordinated by the protein and lithium halogenides, and lithium halogenides are coordinated by carbohydrate.

Stabilities calculation of the complexes of molecular iodine with lithium halogenides, carbohydrates, and lateral amino acid residues of proteins suggests that in the process of molecular iodine intercalation in the system there are complexes formed (IV-VII Fig. 8), in which molecular iodine is coordinated by the protein, and lithium halogenides and lithium halogenides are coordinated by carbohydrate.

Table 4 shows the coordination bond lengths and ΔE for stabilization energy of complexes.

ΔE are calculated as follows:

$$\Delta E = E_1(\text{compl.}) - (E_2 + E_3), \quad (9)$$

where, E_1 is total complex energy, E_2 - total $\text{LiClOHC}_2\text{H}_5$ energy;

E_3 – total energy of I_2 complex with amino-acid residue.

As can be seen from Table 4, the most stable complex is formed with participation of arginine (structure VII), in this case I-I bond breaks; in such a complex the properties of molecular iodine are not preserved. Comparison of the stabilization energies for complexes of molecular iodine with arginine (-18.17 kJ/mol), and with adenosine (-10.93 kcal/mol) and guanine (-11, 50kJ/mol), suggests that if arginine is included in the ABA composition, I_2 molecule remains in the structure of the formulation and will not form a complex with DNA-nucleotides.

In I-III complexes I-I bond does not break, but is weakened only. After arginine the most stable complexes are obtained with participation of carbonyl group of protein amide fragment. Amide fragment is a part of polypeptide skeleton and is a part of amino-acid residue of asparagine and glutamine.

The output of final product depends on physico-chemical parameters of the reaction – K_{rev} , stoichiometric coefficient n , and concentration of reagents.

Based on the data of UV, Fourier transform IR spectroscopy, electron and optical microscopy, quantum-chemical calculations, the structure of ABA and sequence of acts in formation of this structure, according to the method for ABA preparation, schematically can be represented as follows (Fig. 9).

Formation of ABA subunit (molecule) occurs after the influence of ionic strength in the range from 0,015 and up to 10.2, corresponding to the pressure of 286 - 2860 kg/cm². After the influence of such pressure (ionic strength), carbohydrate and protein macromolecules are packed in such a way that terminal amino acid triplets not involved in complexation are oriented outwards from the core protein and/or polypeptide skeletal chain, and perform anchoring of antibacterial agent on the cell membrane through chain-terminal amino acids,

containing electron-donor functional groups, which is directly evident from the data on ABA immunothropic action, given below.

A method for the claimed ABA preparation is the following:

A carbohydrate sample is dissolved in an appropriate solvent such as water, dioxane and other. In this solution, in order to obtain complex compounds certain samples of metal salts and sodium chloride are added to generate the appropriate ionic strength of the solution (Product A).

A protein sample is dissolved in an appropriate solvent such as water, dioxane and other. In this solution, to obtain complex compounds certain samples of metal salts and sodium chloride are added to generate the appropriate ionic strength of solution (Product B).

A sample of crystalline iodine or iodine and potassium iodide is dissolved in an appropriate solvent such as chloroform, hexane and others, and the solution stirred until complete iodine dissolving (Product C).

Then to the mixture of Products A and B, 70% of Product C is added in portions while stirring. After stirring the reaction mixture for 1 hour at $42\div 43^{\circ}\text{C}$, a protein with specific immunothropic functions containing at least one terminal amino acid with electron-donor functional groups is added to the solution, and a final 30% iodine intercalation is conducted by adding in portions the remaining 30% of Product C. The resulting antibacterial agent (ABA) (a complex compound of iodine with carbohydrates and/or proteins and metal salts), is extracted using a suitable method, and dried. A drug based on this antibacterial agent was prepared using the known methods, in a form of a solution for oral administration, solution for parenteral use, tablets and capsules.

Analysis of the antibacterial agent was performed by color-indication, potentiometric titration (Sartorius Professional Meter PP-50), capillary electrophoresis (Agilent Technologies CE3D, USA), vibrational (IK) spectroscopy with Fourier transform (Thermo Electron Corporation Nicolet 6700), electron spectroscopy in ultraviolet and visible spectrum (PerkinElmer Lambda 35).

Microscopy of complex compounds was performed in a scanning electron

microscope Quanta 200i 3D (FEI Company, USA).

The product cytotoxicity was determined *in vitro* by microscopy and using MTT-test in monolayer subinoculated cell cultures RD, MDCK, MRC-5, suspension cultures of MT-2 and H9 by micromethod in 96-well plates, incubated in an atmosphere containing 5% CO₂ at 37°C (Table 5).

Determination of ABA minimum inhibitory concentration (MIC) against clinical isolates of MRSA and MSSA, and reference strains of *Staphylococcus aureus* ATCC 43300 and *Staphylococcus aureus* ATCC 29213 was conducted by serial dilution method in culture medium [*Clinical Laboratory Standards Institute, Document M7-A7. Methods for dilution antimicrobial susceptibility tests for bacteria that grow aerobically; Approved standard-7 th Edition, Wayne, Pa: Clinical Laboratory Standards Institute, 2006*] (Table 6).

Studies of ABA synergistic action with antibiotics against clinical isolates of MRSA and MSSA, and reference strains of *Staphylococcus aureus* ATCC 43300 and *Staphylococcus aureus* ATCC 29213 were conducted by Checkerboard method [*Eliopoulos G and Moellering R. Antimicrobial combinations. In Antibiotics in Laboratory Medicine, 1996, 4rd edn (Lorian, V., Ed.), Pcl. 331-396. Williams and Wilkins Co., Baltimore, MD, USA*].

Determination of synergy by Time-Kill method was conducted in relation to control strain of MRSA ATCC 43300 [*National Committee for Clinical Laboratory Standards, Document M26-A. Methods for Determining Bactericidal Activity of Antimicrobial Agents; Approved Guideline Wayne, Pa: National Committee for Clinical Laboratory Standards, 1999*].

Antimycobacterial effect of ABA FS-1 was studied based on growth dynamics of mycobacterial strains of *M.tuberculosis* H37Rv, *M.tuberculosis* MS-115 and *M.bovis* *Bovinus* in enriched liquid medium Middlebrook 7H9 in the presence of different concentrations of the product, compared with the growth of these strains on a medium containing no drugs, and on a medium containing the first-line agent isoniazid at concentration of 0.1 µg /ml. The studies were conducted in triplicates.

Growth detection was carried out using an automated growth record system for cultures Bactec MGIT 960 (Becton Dickenson, USA) in special MGIT tubes. Growth detection of mycobacterial cultures was performed every hour using Epicenter software (Becton Dickenson, USA).

To study antituberculous effect of the product made from ABA in Example 5 (FS-1) an aerogenic infection model was used in female albino guinea pigs. Inoculation was performed in aerosol chamber "GlasCol" with a dose of 150 CFU of *M. tuberculosis H37Rv* per a lung.

To study antituberculous effect of FS-1 the *Dunkin Hartley* line guinea pigs were used. The inoculation was carried out intramuscularly on the basis of 0.5 ml of suspension containing $\approx 307 - 692$ of *M. tuberculosis H₃₇R_v* bacterial bodies in 1 ml per animal.

Determination of ABA antiviral action *in vitro* against influenza virus A/FPV/Waybrige/78/H7N7 and herpes simplex virus, strain "Victory", was performed using micromethod on subinoculated MDCK and RD cell cultures. Substances were added in concentrations equal to 1/2, 1/4, 1/8, 1/16 of the maximum tolerated concentration (MTC).

The study of FS-1 antiviral action against human immunodeficiency virus HIV-1 (LAI) was conducted in cell culture MT-2 (human T-lymphoblastoid cells transformed with HTLV-1 virus), with azidothymidine as the reference substance.

The source of virus-containing material was a culture fluid of N9/HTLV-IIIB line cells, chronically infected with human immunodeficiency virus HIV-1 strain (LAI).

Evaluation of FS-1 mutagenic activity in the Ames test was carried out in 4 mutagenic (auxotrophic for histidine) strains of *Salmonella thyphymurium*: TA 98, TA 100, TA 102, and TA 1535 with metabolic activation and without metabolic activation.

The study of DNA-damaging activity of FS-1 in the comet assay was performed *in vitro* in the mouse lymphoma cell line L5178Y and human hepatoma cell line HepG2.

The study of ABA cytogenetic activity was performed by taking account of chromosome aberrations in bone marrow leukocytes of mammals *in vivo* in mice.

The study of ABA cytogenetic activity was performed using micronucleus test in polychromatic and orthochromatic erythrocytes of mice's bone marrow cells *in vivo*.

The study of dominant lethal mutations in spermatozoa in mammals, when administered FS-1, was performed *in vivo* in mice.

Most of the examples given in the description illustrate the ABA effectiveness against pathogenic microorganisms, including museum and clinical isolates of multidrug-resistant (MDR) *Mycobacterium tuberculosis* belong to the ABA-based drug after Example 5 (FS-1), without being limited to them.

Experiments for studying radioprotective properties of the drug ABA FS-1 were conducted in white rats weighing 190-200g and white mice weighing 22-25g. In irradiation experiments the animals were exposed to single uniform radiation in RUM-17 therapeutic x-ray apparatus (180kV, 10mA, filters 0.5 mm Cu + 1.0 Al, focal distance - 40 cm, radiation dose rate - 178 R/min) in doses of 800 R (radiation doses close to LD50).

Induction of myelosuppression with ABA FS-1 was performed by the method of [Galoyan A.A., Korochkin L.I., Rybalkina E.J., Pavlova G.V., Saburina I.N., Zarski E.I., Galoyan N.A., Davtyan T.K., Bezirganyan K.B., Revishchin A.V. Hypothalamic proline-rich polypeptide enhances bone marrow colony-forming cell proliferation and stromal progenitor cell differentiation // Cell Transplantation. – 2008. – Vol. 17. – P. 1061-1066].

Sampling of peripheral blood and bone marrow of animals was carried out by the method of [Bezirganyan KB, Davtyan TK, Galoyan AA Hypothalamic proline rich polypeptide regulates hematopoiesis // Neurochem. Res. - 2010. - Vol. 35. - CL. 917-924. Gershanovich M.L., Paikin M.D. Symptomatic treatment of malignancies. 2nd ed. - Moscow: Medicine, 1986. – 285 p.].

Assessment of myelosuppression was performed by counting the absolute and relative content of leukocytes, lymphocytes and monocytes in peripheral blood

using an automated hematology analyzer Celly v 2.20, Hycel Diagnostics.

The recovery of bone marrow hematopoietic function was estimated using clonogenic test. [Bezirganyan K.B., Davtyan T.K., Galoyan A.A. Hypothalamic proline rich polypeptide regulates hematopoiesis // Neurochem. Res. - 2010. - Vol. 35. - CL. 917-924], by determining the number of granulocyte-monocyte colony-forming (CFU-GM) progenitor bone marrow cells. For this purpose, bone marrow cells were cultured in a medium MethocultTM GF R3774, containing methylcellulose and growth factors, progenitor cells (stem cell factor, GM-CSF and IL-3), StemCell Technologies Inc (cat № 03774).

Example No. 1 FS-1.1

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. Temperature is maintained using thermostat "HUBER" - Ministat 230 CC2. 130g of carbohydrate is dissolved in 500 ml of water at 50°C. Further, 3.0g of sodium chloride and 1.98mg of calcium chloride dissolved in 100ml of water are added. The mixture is thoroughly stirred and cooled to 43°C (Product A).

5.0 g of albumin are dissolved in 150 ml of water and then 3.96g of lithium chloride, 8.4g magnesium chloride and 2.0g of sodium chloride added (Product B). 135 ml of the resulting solution is poured in the reactor. Reactor mixture is agitated for 20 minutes, and after that the solution temperature reduced to 25 °C.

0.82 g of I₂ and 1.2 g of potassium iodide are dissolved in 100 ml of water (Product B). 70 ml of the resulting solution is poured in portions in the reactor. Iodine intercalation is performed for 2 hours at 25 °C, and after that the rest 15ml of Product B are added. After 1 hour, another 30 ml of Product B is added in portions into reactor, and iodine intercalation is completed within 2 hours.

Ionic strength of the solution is 13.6.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, for example, centrifugal chromatography method in "Kromaton" FCPC (Fast Centrifugal Chromatography), and dried (Fig.

10(a)).

Analysis results:

	Dextrin	Albumin	polyvinyl alcohol (PVA)	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole fractions, %	0.40	0.59	63.58	0.02	0.01	11.62	10.62	2.21	10.95

$$[5280L_1 \cdot 1,5L_2 \cdot 33I_2] \cdot L_3$$

Example No. 2 FS-1.2

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 108.3g of dextran is dissolved in 500 ml of water at 45°C. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 2.5g of polyvinyl alcohol (hereinafter PVA) dissolved in 150 ml of water, 4.0 g of sodium chloride and 1.65g of calcium chloride dissolved in 100ml of water, are added. The mixture is thoroughly stirred and cooled to 43°C (Product A).

4.17g of albumin is dissolved in 150 ml of water, and then 3.3g of lithium chloride, 7.0g of magnesium chloride and 0.17g of sodium chloride are added. The resulting solution is transferred to the reactor when the temperature of Product A specified above is reached. The mixture is stirred for 20 minutes, and after that the temperature of reaction zone is reduced to 25°C (Product B).

2.0g of I₂ and 3.0g of potassium iodide are dissolved in 100 ml of water. The resulting solution is poured in portions into the complex compound solution (Product B). Iodine intercalation is performed for 4 hours at 25°C.

Ionic strength of the solution is 13.2.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10 (b)).

Analysis results:

	Dextrin	Albumin	PVA	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole fractions, %	62.35	0.02	0.01	11.40	10.40	10.74	2.2	1.15	1.73

$$[38L_1 \cdot 1,5L_2 \cdot 97I_2] \cdot L_3$$

Example No. 3 FS-1.3

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 72.0 g of carbohydrate is hydrolyzed in 600 ml of water at 60°C. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 1.7 g of PVA dissolved in 100 ml of water; 2.8g of sodium chloride and 1.1g of calcium chloride dissolved in 100ml of water are poured in. The mixture is thoroughly stirred and cooled to 43°C (Product A).

2.8 g of albumin is dissolved in 150 ml of water, and then 2.2 g of lithium chloride, 4.66 g of magnesium chloride and 0.8 g of sodium chloride are added. The resulting solution is transferred to the reactor when the temperature of Product A specified above is reached. The mixture is stirred for 20 minutes, and after that the temperature in reaction zone is reduced to 25°C (Product B).

Ionic strength of the solution is 10.8.

4.1 g of I₂ and 6.0g of potassium iodide are dissolved in 100 ml of water. The resulting solution is poured in portions into the complex compound solution (Product B). Iodine intercalation is performed for 4 hours at 25°C.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10 (c)).

Analysis results:

	Dextrin	Albumin	PVA	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole fractions, %	0.96	0.04	0.03	24.38	22.46	22.95	4.65	7.57	16.96

$$[611L_1 \cdot 24L_2 \cdot 294I_2] \cdot L_3$$

Example No. 4 FS-1.4

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 72.0 g of carbohydrate is hydrolyzed in 550 ml at 100°C. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 1.7 g of PVA dissolved in 250 ml of water is poured in (Product A). The mixture is thoroughly stirred during 20 min, after that the temperature in reaction zone is reduced to 25°C.

4.1 g of I₂ and 6.0g of potassium iodide are dissolved in 200 ml of water. The resulting solution is poured in portions into the complex compound solution (Product B). Iodine intercalation is performed for 4 hours at 25°C.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10 (d)).

Ionic strength of the solution is 3.02.

Analysis results:

	Carbohydrate	PVA	I ₂	KI
Mole fractions, %	29.67	66.45	3.78	0.10

$$[37L_1 \cdot 294I_2] \cdot L_3$$

Example No. 5 FS-1

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 130 g of mixture of amylase and amylopectin in the ratio of 1:4 is dissolved in 500 ml of water at 43°C. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 3.0 g of PVA dissolved in 150 ml of water, 4.5 g of sodium chloride, and 2.0 g of calcium chloride dissolved in 100 ml of water are poured in (Product A).

5.0 g of albumin is dissolved in 150 ml of water, and then 4.0 g of lithium chloride, 8.4 g of magnesium chloride and 0.5 g of sodium chloride are added. The resulting solution is transferred to the reactor. The mixture is stirred for 20 minutes, and after that the temperature of reaction zone is reduced to 25°C (Product B).

8.2 g of I₂ and 12.1 g of potassium iodide are dissolved in 100 ml of water. The resulting solution is poured in portions into the complex compound solution (Product B). Intercalation of iodine is carried out in two stages, as described in the previous examples.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 11).

Ionic strength of the solution is 20.60.

Analysis results:

	Amylum	Albumin	PVA	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole fracture, %	0.94	0.04	0.02	23.90	21.62	22.31	4.56	8.17	18.44

$$[38L_1 \cdot 2L_2 \cdot 333I_2] \cdot L_3$$

Example No. 6 FS-1.5

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 24.1 g of carbohydrate is hydrolized in 500 ml of water at 80°C until a certain molar weight is reached. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 2.8 g of PVA dissolved in 150 ml of water is poured in. The mixture is thoroughly stirred and cooled to 43°C (Product A).

34.0 g of I₂ and 50.5 g of potassium iodide are dissolved in 100 ml of water. The resulting solution is poured in portions into the complex compound solution (Product C). Intercalation of iodine is carried out in two stages, during 4 hours at 25°C.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10 (d)).

Ionic strength of the solution is 25.3.

Analysis results:

	Carbohydrate	PVA	I ₂	KI
Mole fractures, %	0.16	0.02	30.50	69.32

$$[8L_1 \cdot 1488I_2] \cdot L_3$$

Example No. 7 FS-1.6

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 24.1 g of carbohydrate is hydrolized in 500 ml of water at 100°C until a certain molar weight is reached. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 2.8 g of PVA dissolved in 150 ml of water, 0.8 g of sodium chloride, and 0.37 g of calcium chloride dissolved in 100 ml, are poured in. The mixture is thoroughly stirred and cooled to 43°C (Product A).

0.93g of albumin is dissolved in 150 ml of water, and then 0.73g of lithium chloride, 1.55g of magnesium chloride and 0.13g of sodium chloride are added. The resulting solution is transferred to the reactor after the required Product A temperature specified above is reached. The mixture is stirred for 20 minutes

(Product B) and after that the temperature of reaction zone is reduced to 25 °C.

34.0 g of I₂ and 50.5 g of potassium iodide are dissolved in 100 ml of water. The resulting solution is poured in portions in the complex compound solution (Product C). Intercalation of iodine is carried out in two stages, during 4 hours at 25°C.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10(e)).

Ionic strength of the solution is 27.9.

Analysis results:

	Carbohydrate	Albumin	PVA	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole fractures, %	0.14	0.006	0.02	3.51	3.23	3.31	0.68	27.23	61.70

$$[26L_1 \cdot L_2 \cdot 4970I_2] \cdot 3L_3$$

Example No. 8 FS-1.7

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, after the constant stirring. 130.0 g of dextrin and 3.0 g of PVA is dissolved in 500 ml of water at 50°C. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 4.0 g of sodium chloride and 2.0 g of calcium chloride dissolved in 100 ml of water are poured in. The mixture is thoroughly stirred and cooled to 43°C (Product A).

5.0 g of albumin is dissolved in 150 ml of water, and then 4.0 g of lithium chloride, 8.4 g of magnesium chloride and 1.0g of sodium chloride are added. The resulting solution is transferred to the reactor after the required Product A temperature specified above is reached. The mixture is stirred for 20 minutes (Product B), and after that the temperature of reaction zone is reduced to 25°C.

8.2 g of I₂ and 12.1g of potassium iodide are dissolved in 100ml of water. 70

ml of the resulting solution is poured in portions in the complex compound solution (Product B). Iodine intercalation is carried out in two stages during 4 hours at 25°C.

0.6g of IL-2 is dissolved in 150 ml of water and slowly added to the reactor. 30 minutes after the charge of IL-2, 20 ml of Product B is added to the reactor. The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10(f)).

Ionic strength of the solution is 20.60.

Analysis results:

	Dextrin	Albumin	IL-2	PVA	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole percent, %	0.94	0.04	0.01	0.02	23.9	21.62	22.30	4.56	8.17	18.44

$$[79L_1 \cdot 3L_2 \cdot II - 2 \cdot 684I_2] \cdot 2L_3$$

Example No. 9 FS-1.8

ABA synthesis is conducted in the laboratory reactor D-55122 Mainz, type Rührgefäß 2L, QVF ENGINEERING GMBH, under the constant stirring. 13.1 g of carbohydrate is hydrolyzed in 100 ml at 130°C. Temperature is maintained using a thermostat “HUBER” - Ministat 230 CC2. Further, 3.0 g of PVA dissolved in 150 ml of water, 0.3 g of sodium chloride and 0.2 g of calcium chloride dissolved in 100 ml of water are poured in (Product A). The mixture is thoroughly stirred and cooled to 43°C.

0.51 g of albumin is dissolved in 150 ml of water, and then 0.4 g of lithium chloride, 0.84 g of magnesium chloride and 0.2 g of sodium chloride are added.

The resulting solution is transferred to the reactor after the required Product A temperature specified above is reached. The mixture is stirred for 20 minutes (Product B), and after that the temperature in reaction zone is reduced to 25°C.

74.5 g of I₂ and 110.0 g of potassium iodide are dissolved in 500 ml of water. The resulting solution is poured in portions in the complex compound solution (Product B). Intercalation of iodine is carried out in two stages, during 4 hours at 25°C.

The resulting ionic nanostructured ABA complex is extracted from the reaction medium using a suitable method, and dried (Fig. 10(g)).

Ionic strength of the solution is 0.71 mol/L.

Analysis results:

	Carbohydrate	Albumin	PVA	LiCl	NaCl	MgCl ₂	CaCl ₂	I ₂	KI
Mole fractures, %	0.04	0.002	0.01	0.96	0.87	0.9	0.18	29.8	67.31

$$[25L_1 \cdot L_2 \cdot 19575I_2] \cdot 7L_3$$

In biological activity testing it was established that ABA FS-1 is active *in vitro* both against clinical isolates, and control strains of MRSA and MSSA. MIC of antimicrobial agent was varied from 0.938 mg/ml to 0.234 mg/ml.

Tests for synergy with oxacillin have shown a decrease in MIC of both drugs. The decline was from 256 to 64 µg/ml for oxacillin, and from 0.234 to 0.117 µg/ml for ABA FS-1. FIC index for this test was 0.75, which may be regarded as a partial synergy between the tested drugs.

Test for synergy with cefamandole has shown a decrease in MIC of both drugs. The reduction ranged from 64 to 8 µg/ml for cefamandole, and from 0.469 µg/ml to 0.234 µg/ml for ABA FS-1. FIC index for this test was 0.62, which determines the interaction of these antibiotics as a partial synergy.

Test for synergy with lincomycin has shown a decrease in MIC of both drugs. The reduction ranged from 64 µg/ml to 8 µg/ml for lincomycin, and from 0.234 mg/ml to 0.117 mg/ml for ABA FS-1. FIC index for this test was 0.625, which determines the interaction of these antibiotics as a partial synergy.

ABA in Examples 1-9 (FS-1.1 - FS-1.8) has a greater or lesser bactericidal activity against pathogenic microorganisms of different classes (Table 6). The most acceptable and effective one, as follows from Table 6, with respect to *Mycobacterium tuberculosis*, is ABA in Example 5 (FS-1).

As the result of studying FS-1 antimycobacterial action against *M.tuberculosis H37Rv*, *M.tuberculosis MS-115* with multidrug-resistance, and *M. bovis*, it was established that at the drug concentrations in dilutions of 1:12.5, 1:25 and 1:50 a complete suppression of reproduction of mycobacteria was observed throughout the entire registration period.

Bactericidal activity of FS-1 was evaluated *in vitro* using a microbiological method of double serial dilutions in Shkolnikova liquid medium, with subsequent passaging on Levenstein-Jensen medium. *In vitro* bactericidal activity of FS-1 at concentrations ranging from 1.750 to 0.0437 mg/ml in field strains of mycobacteria, drug-resistant clinical isolates and *M. tuberculosis N37Rv* has been established. Bacteriostatic effect of FS-1 is observed in concentrations from 0.0218 to 0.0109 mg/ml.

Bactericidal activity of FS-1 *in vitro* in concentration of 0.0437 mg/ml in combination with anti-antitubercular (hereinafter anti-TB) drugs, Type I, with subsequent passaging on Levenstein-Jensen medium in relation to museum strain *M. tuberculosis N37Rv* and 8 multi-drug resistant strains, was evaluated. The research identified, with various concentrations of anti-TB drugs of Type I, museum sensitive and multidrug-resistant strains. The results are presented in Table 7.

As can be seen from Table 7, after the combined action of FS-1 with different concentrations of anti-TB drugs, the growth of multidrug resistant strains of *Mycobacterium tuberculosis* was not detected in experimental test tubes, i.e. strains were susceptible to all concentrations of anti-TB drugs of Type I, in comparison

with the museum strain, where susceptibility was observed both with FS-1, and without it.

It has been established *in vivo* that administration of FS-1 to infected guinea pigs in a dose of 5mg/kg has reduced the number of plated mycobacteria from the lungs of infected animals, compared with control group of animals. ABA FS-1 has a pronounced anti-inflammatory effect on the clinical course of experimental tuberculosis in guinea pigs, increasing airiness of lung parenchyma twofold.

It has been established *in vivo* that the combined application of anti-TB drugs and FS-1 in a dose of 0.3 ml/kg on the 21st day after the treatment initiation results in complete disappearance of tuberculosis changes in the organs of animals, regardless of the type of resistance of the infecting strain.

According to the results presented in Table 8, it is evident that in Group 3 there was a decrease in the number of tuberculosis lesions in lungs observed, and their complete disappearance on the 35th day after the treatment initiation. In Group 4 disappearance of tuberculosis lesions in lungs and liver was registered on the 28th day after the treatment initiation. In Group 5 disappearance of tuberculosis lesions in lungs and liver was registered on the 21st day after the treatment initiation.

In groups of animals infected with multiresistant strain of mycobacteria resistant to anti-TB drugs, the following results have been observed: in Group 6 there was a progressive clinical course of tuberculosis infection; in Group 7 the disappearance of tuberculosis lesions in lungs and liver was registered on the 35th day after the treatment initiation, in Group 8 a disappearance of tuberculosis lesions in lungs and liver was registered on the 21st day after the treatment initiation.

Medicinal agent after the Example 5 (FS-1) in combination with anti-TB drugs, both in the group of animals infected with strains of *M. tuberculosis H37Rv*, and in the group infected with multiresistant strains of mycobacteria, has a therapeutic effect on the clinical course of tuberculosis. Pathological changes that are typical in tuberculosis disappear after 21 and 28 days respectively (groups 4 and 7).

Animals in the control group who did not receive any treatment, tuberculosis process moved into a generalized form with overall visceral injury (groups 1 and 2).

Although any mechanism offered to explain the mechanism of the complex compound action should not be regarded as restrictive, it is most likely that antimicrobial activity of ABA is related to: a) the structure of biologically active carbohydrates and peptides; b) oxidizing action of iodine molecules both on the cell membrane, and on the cell structure in diffusion of the active substance through the membrane of bacterial cell; c) halogenation of DNA of microorganisms; d) interferons induction in the course of impact of complex compound on immunocompetent cells; e) activation of monocytes-macrophages and cytotoxic T-lymphocytes.

ABA studied after the Examples 1-9 *in vitro* have a greater or lesser virucidal activity against influenza, herpes and HIV-1 immunodeficiency viruses (Tables 9-13).

In the studies of FS-1 antiviral action *in vitro* on subinoculated cell cultures, anti-HIV activity of FS-1 was identified in cell culture against laboratory strain of HIV-1 (LAI). The decline in infectivity indices for HIV virus - p24 content and reverse transcriptase - after the drug-induced action indicates the virusocidal action of the drug against human immunodeficiency virus. Application of FS-1 at doses of 0.188 mg/ml and 0.094 mg/ml, or azidothymidine in a dose of 0.01 mg/ml resulted in a significant decrease in extinction as compared to placebo and, consequently, a decrease of p24 protein of human immunodeficiency virus (infectivity index for the virus) by 60 times (Table 12).

Application of FS-1 at doses of 0.094 mg/ml and 0.188 mg/ml, decreased the content of reverse transcriptase - infectivity index for the virus - compared with negative control by 4.1 and 12.7 times. On application of azidothymidine as a positive control at a dose of 0.01 mg/ml, this figure dropped by 5 times only (Table 13).

Antiviral activity of the drug FS-1 against influenza viruse

A/FPV/Rostock/34 has been established *in vitro* and *in vivo* (Tables 14-16).

Thus, survival rate of chickens infected with influenza virus at a dose of 100 EID₅₀/0.1 ml after prophylactic use of the drug FS-1 at doses of 0.290 mg / kg and 1.458 mg / kg was 100%, and after prophylactic use of rimantadine - $28 \pm 12.53\%$. All control chickens that received saline solution died (100% mortality).

Studies of cytotoxicity and efficacy of ABA in Examples 1-9 have identified three main compounds that were tested with a view of acute toxicity. Toxicological studies were conducted in laboratory animals in compliance with bioethics standards (Guide for the Care and Use of Laboratory Animals. Washington: National Academy Press. 1996). To establish parameters of acute toxicity (LD50) ABA was administered enterally and parenterally in mice and rats.

Results of acute toxicity of three ABA in enteral and paraenteral routes of administration in outbred mice are shown in Tables 17, 18.

The least toxic substance has proven to be ABA FS-1. In enteral (intra-gastric) administration to mice and rats, FS-1 lethal effect was not achieved because the maximum amount of drug administered was 1 ml and 5 ml, respectively, while doses were 922 and 496 mg/kg, respectively. Macroscopic studies of the internal organs of dead animals revealed that the cause of death appears to be associated with impaired hemodynamics, which is indirectly confirmed by the development of disseminating inopexia and severe blood fullness in internal organs of the animals that died. By the end of the 14th day, no abnormalities in the structure of internal organs and tissues have been detected through pathomorphological studies in surviving animals against the control group. In this case, significant injuries of mucous membranes in the gastrointestinal tract were not identified. Cumulation coefficient (C_{cum}) was 1.85, which according to the international drug toxicity scale corresponds to the parameters of drugs with faint cumulative effect.

Further a study was conducted for chronic toxicity in rats and rabbits with intra-gastric method of administration for 60 days and 30 days recovery period at

doses of 5.0 mg/kg (dose is equivalent to 1/100 of MTD established in rats) and 50 mg/kg (dose equivalent to 1/10 of MTD established in rats).

Chronic administration of the drug at a dose of 5.0mg/kg caused no deviations from the control group of animals in terms of body weight dynamic, physical, hematological, and biochemical indices of blood and urine. No abnormalities in cardiac cycle have been observed. All animals kept normal macro-and microstructure of the internal organs.

Chronic administration of the drug in rats and rabbits at a dose of 50.0 mg/kg caused the following toxic effects. On the part of blood biochemical parameters there was a slight increase in liver enzymes: alanine transaminase, aspartate aminotransferase, and alkaline phosphatase, as well as components of nitrogen metabolism: creatinine, urea. Some animals were found to have venous plethora, hepatocytes with signs of degenerative changes in the cytoplasm; there were nonerosive petechial hemorrhages observed in the stomach wall. Some animals had small intestine coat swelling. Changes of thyroid gland in animals of this group were very diverse and unique. In general, there has been a decrease in functional activity of thyroid gland due to appearance of large follicles and flattening of epithelium. However, studies conducted on the 90th day of the experiment (30th day of recovery period) have shown that the identified biochemical changes and microstructure changes of internal organs were reversible.

Reproductive toxicity was studied in mice. Females before and during pregnancy were administered the medicine after the Example 5 intragastrically and intramuscularly. The research results are presented in Table 19.

It has been established that intragastric administration (before and after pregnancy) did not result in premature delivery in mice, even when testing the drug in higher doses (100 mg/kg).

Embryotoxicity study was carried out in chicken embryos. It has shown that ABA doses after the Example 5, up to 12.5 mg/ml, do not have a pathological effect on embryos' development at different stages.

In the study of carcinogenic activity of the drug after the Example 5 (FS-1) a

battery of tests was used, which included: identification of genotoxic activity in SOS Chromotest for *E.coli* Ec 1000 (PJ E 43); identification of single-strand DNA breaks and determination of the repair (unscheduled) DNA synthesis in blood cells and cell culture of rhabdomyosarcoma in concentrations ranging from 1 to 2000 µg/ml. Results of studying carcinogenic activity of FS-1 are presented in Table 20. In the conditions used the tested FS-1 is not a SOS response inducer in cells of tester strain of *E.coli* Ec 1000 (PJE43).

A negative result was identified (absence of single-strand DNA breaks) when exposed to 200, 300, 600 µg/ml of FS-1.

Genotoxic activity of the drug after the Example 5 was studied in the induction test of unscheduled (reparative) DNA synthesis in cells of donor's peripheral blood. It was shown that in the concentration range of 50, 100, 200 µg/ml there is no stimulation of unscheduled synthesis detected, whether with metabolic activation or without it.

In the experiments, both without metabolic activation, and with metabolic activation, during Ames test no significant changes in growth activity of all four mutagenic strains of *Salmonella thyphymurium* being studied were detected after the influence of FS-1 as compared with the negative control.

At that this lack of effect on growth of mutagenic strains was registered for its relatively high concentrations as well, such as 1.0 and 2.0 mg/cucl. Therefore, FS-1 is not mutagenic in relation to DNA of histidine auxotrophic strains of *Salmonella thyphymurium* in Ames test.

Analysis of FS-1 DNA-damaging effect for both mouse lymphoma L5178Y cells, and human hepatoma HepG2 cells revealed no significant increase of spontaneous formation of comet (tailed) DNA in the cells of these lines. Moreover, the absence of the drug inducing effect on formation of comet (tailed) DNA in the cytoplasm of both types of studied cell lines was also revealed in the presence of metabolic activation by liver enzymes in mice. Consequently, the drug in the studied range of concentrations, even in such large ones as 1.0 and 2.0 mg/ml, has no damaging effect on eukaryotic DNA, *in vitro*, both in the absence, and

following its metabolic activation.

Table 21 presents the results of cytogenetic activity studying. No statistically significant differences in the level of bone marrow leukocytes with chromosomal aberrations were detected, and no quantity and quality of chromosomal aberrations in them after the influence of a single administration of FS-1 in a dose of 22 mg/kg of animal weight was found. Moreover, the repeated administration of FS-1 in a dose of 8 mg/kg of animal weight was also characterized by lack of its impact on both the number and character of chromosomal aberrations in bone marrow leukocytes as compared with control (Table 21).

Therefore, FS-1 in the investigated doses has no damaging effect on eukaryotic DNA *in vivo*.

Data presented in Table 22 shows that after the single FS-1 administration in a dose of 22 mg/kg of animal weight there is no increase in the content of polychromatic and normochromatic bone marrow erythrocytes with micronuclei, and in the number of micronuclei in them. Additionally, the repeated drug administration at a dose of 8 mg/kg of animal weight is also characterized by the absence of its effect both on the number of polychromatic and normochromatic erythrocytes containing micronuclei, and on the total number of micronuclei in erythrocytes compared with control (Table 22).

Consequently, the medicinal agent in the investigated doses has no damaging effect on eukaryotic DNA, in particular a release of part of DNA from nucleus in the form of micronucleus, *in vivo* in the course of their normal development.

The results of the experiment on the studying induction of dominant lethal mutations by FS-1 in germ cells have demonstrated that the level of postimplantation losses in animals exposed to the drug through its intramuscular injection at a dose of 22 mg/kg (test group 1.1 - 1.3) of animal weight, did not change as compared with the control group (Table 23).

Therefore, FS-1 when administered into a body in investigated doses, does not induce development of dominant lethal mutations in germ cells (mature sperm cells,

late and early spermatids) in mammals *in vivo*, i.e. it has no mutagenic activity in the test for dominant lethal alleles.

Results of numerous experiments on the testing FS-1 mutagenic activity in testing systems with different sensitivity, both *in vitro*, and *in vivo*, have demonstrated that the drug is not mutagenic, even in its significant quantities. This indicates that FS-1 in its interaction with eukaryotic cells, including actively dividing and germ cells, which belong to the category of highly susceptible, does not have a DNA-damaging and specific mutagenic effects on them, i.e. it does not cause DNA damage and/or dysfunctions in the normal implementation of genetic apparatus.

In the event of ionizing radiation dose exposure, namely, 800 R, in the group of mice that received 0.15 ml of FS-1 prior to irradiation a certain radioprotector effect was achieved. So, while in the control group by the end of 30 days a survival rate was 30%, and mean lifetime 18.9 ± 0.4 days, in the experimental group these figures were 70% and 24.6 ± 0.7 days respectively. Statistical analysis of the results (mean lifetime) using Student's t test has shown a significant difference (30%) in respect of mean lifetime ($p < 0.05$).

In an experiment in rats at a dose of 800 R at the end of observation period 26.7% of rats survived, and mean lifetime in this group was 17.2 ± 0.5 days. In rats, who before exposure to 800 R dose, received intragastrically 1.0 ml of FS-1, survival rate was 50%, and mean lifetime lengthened by 24% (21.3 ± 0.8 days) (Fig. 12). And in this case there was a certain radioprotector effect. Statistical analysis of the results (mean lifetime) using Student's t test showed significant difference with respect to mean lifetime ($p < 0.05$). Comparing the results of experiments, we can conclude that FS-1 has a certain radioprotective effect which manifests itself in the animals irradiated at doses that are close to semilethal (LD_{50}).

According to research made by Venturi (2000), iodine was the first antioxidant at the dawn of life in our planet, which has played an enormous role in human evolution. It is well known that the main damaging radiation factor is free radicals formed in the body immediately after irradiation (Bacq, 1965; Alexander, Bacq,

1974; Halliwell, 1985, 1991). Antioxidants, including iodine, bind free radicals, preventing their interaction with biomolecules of the body (Shimoi, 1996; Halliwell, 1985, 1991).

Effectiveness of therapeutic action of medicinal agent based on ABA after the Example 5 (FS-1) has been established in clinical trials in three groups of volunteer patients with MDR pulmonary tuberculosis (Table 24).

The first group (n = 19) received a combined therapy with anti-TB drugs of Type II, as well as ABA after the Example 5 in a dose of 0.1 ml/kg of body weight. The second group (n = 17) received anti-TB drugs of Type II, and placebo in a dose of 0.1 ml/kg of body weight; the third group (n = 19) received anti-TB drugs of Type II and FS-1 in a dose of 0.125 ml/kg of body weight. All drugs were administered once daily.

Drug safety study based on hemostasis (APTT, prothrombin index, thrombin time, fibrinogen) during the 1st month of complex treatment of patients with resistant pulmonary tuberculosis has shown that FS-1 in the used doses of 0.1 and 0.125 mg/kg had no effect on blood coagulation. Moreover, thyroid ultra sound examination after one month of therapy did not detect any kinds of changes in the subjects.

According to the drug susceptibility testing of *Mycobacterium tuberculosis* the resistance to TB drugs (hereinafter - TBD) of Type I (isoniazid (H), rifampicin (R), ethambutol (E), streptomycin (S)) has been proven. Patients were randomized into 3 groups: group 1 (primary) received TBD of Type II (cycloserine (Cs), ofloxacin (Ofs), PAS, protionamid (Pto), capriomicine(Cm)) + FS-1 (0.1 ml / kg); group 2 (primary) received TBD of Type II (cycloserine (Cs), ofloxacin (Ofs), PAS (Pas), protionamid (Pto), Capriomicin (Cm)) + FS-1 (0.125 ml/kg); group 3 (control) received TBD of Type II (cycloserine (Cs), ofloxacin (Ofs), PAS (Pas), protionamid (Pto), capriomicin(Cm)) + placebo).

The average age of subjects was 33.14 ± 9.03 (years), among them - 75.8% men and 24.2% - women. Among clinical forms the most frequent form was infiltrative – 70.1%, less frequent - fibrocavernous – 28.2%. The groups were

homogeneous, no significant differences in background characteristics were observed.

Preliminary study of therapeutic efficacy of the drug indicates that smear conversion was significantly higher in the primary groups starting from the 3rd month of therapy, which proves the efficacy of FS-1 in combination therapy (Table 28).

The data presented in Table 29 also show that starting from the 3rd month of therapy a negative culture is significantly higher in the primary groups compared to the control one, which proves FS-1 efficiency in TB treatment.

The classical method for sputum inoculation of solid medium (Table 30) also suggests that in patients with resistant TB receiving FS-1 in combination with anti-TB drugs of Type II, the specific weight of bacterial examination with negative results was significantly higher compared with control after two months of therapy, which can be traced also after 3 and 4 months.

Changes in X-ray patterns of MDR tuberculosis patients receiving FS-1 in combination with anti-TB drugs of Type II suggest that as early as after one month of therapy, the positive dynamics was significantly higher than in the control group (placebo + TBD, type II), that is, the resorption of infiltration, induration of focuses, and regression of cavities (Table 31) start earlier.

As can be seen in Table 32, there is a weight gain observed in the main group, whereas in the control group, on the contrary, the weight is decreased, and after 3 months the significant changes in body weight are evident in group 1 and group 2, and after 4 months – in group 3.

Preliminary results of Phase II clinical trials prove the efficacy of FS-1 application in the combined antipththisic therapy in patients with MDR TB.

Table 1 – ABA composition

Example No.	Compound	I ₂ , g/L	KI, g/L	Carbohydrate, g/L	Protein		PVA, g/L	LiCl, g/L	NaCl, g/L	CaCl ₂ , g/L	MgCl ₂ , g/L	Ionic strength
					Albumin, g/L	IL-2 mg/L						
1	FS-1.1	0.82	1.2	130.0	5.0	—	3.0	3.96	5.0	1.98	8.4	13.6
2	FS-1.2	2.0	3.0	108.3	4.17	—	2.5	3.3	4.17	1.65	7.0	13.2
3	FS-1.3	4.1	6.0	72.0	2.8	—	1.7	2.2	2.8	1.1	4.66	10.8
4	FS-1.4	4.1	6.0	72.0	—	—	1.7	—	—	—	—	3.02
5	FS-1	8.2	12.1	130.0	5.0	—	3.0	4.0	5.0	2.0	8.4	20.60
6	FS-1.5	34.0	50.5	24.1	—	—	2.8	—	—	—	—	25.3
7	FS-1.6	34.0	50.5	24.1	0.93	—	2.8	0.73	0.93	0.37	1.55	27.9
8	FS-1.7	8.2	12.1	130.0	5.0	0.6	3.0	4.0	5.0	2.0	8.4	20.60
9	FS-1.8	74.5	110.0	13.1	0.51	—	3.0	0.4	0.5	0.2	0.84	56.3

Table 2 - Output of complex Mg₂ + n4I₃-n₆ depending on I₂ excess compared to the stoichiometric content, %

Calculated	78	86	94
Experimental	74	82	93
I ₂ excess from	0	20	50

Table 3 - Output of complex $\text{Ca}^{2+}_{\text{n}5}\text{I}^{-}_{3\text{n}7}$ depending on I_2 excess compared to the stoichiometric content, %

Calculated	71	82	89
Experimental	68	76	85
I_2 excess from	0	20	50

Table 4 - Spatial (lengths of coordination bonds (Å)) and energy (stabilization energy ΔE , kcal/mol) characteristics of I-IV complexes.

	I	II	III	IV
Li - I	2.93	2.96	2.97	2.80
N(O)-I	2.46	2.40	2.76	2.18
I-I	2.76	2.82	2.72	3.03
$-\Delta E$	16.60	14.26	6.25	24.25

Table 5 - CC 50 and MNC for different series of the substance FS-1 in MDCK cell culture after 72-hour incubation

Example №	Compound	Drug dilutions	
		CC 50	MNC
1	ABA -1 (FS-1.1)	1:50	1:100
2	ABA -2 (FS-1.2)	1:800	1:3200
3	ABA -3 (FS-1.3)	1:100	1:200
4	ABA -4 (FS-1.4)	1:50	1:6400
5	FS-1	1:20	1:80
6	ABA -6 (FS-1.5)	1:1460	1:3200
7	ABA -7 (FS-1.6)	1:5063	1:6000
8	ABA -8 (FS-1.7)	1:565	1:1500
9	ABA -9 (FS-1.8)	1:3637	1:6400

Table 6 - Bactericidal activity against microorganisms of different pathogenicity groups

Microorganism name	Minimum inhibitory concentration of the complex compound after the Example, mg/ml								
	1	2	3	4	5	6	7	8	9
<i>Escherichia coli</i> INMIA 5002 (ATCC 11303)	2.5	1	1	1	1	2.5	1	1	2.5
<i>Escherichia coli</i> INMIA 5230	2.5	1	1	1	1	2.5	1	1	2.5
<i>Staphylococcus aureus</i> INMIA 5233	2.5	1	1	1	1	5	1	1	2.5
<i>Serratia marcescens</i> INMIA 5251 (ATCC 9986. Bu 211. IFO 3736)	2.5	1	1	1	2.5	5	1	1	2.5
<i>Mycobacterium spp</i> INMIA 5237 (B-5 strain)	7	1	1	1	0.0437	7	1	1	7
<i>Pseudomonas fluorescens</i>	2.5	1	1	1	0.5	2.5	1	1	2.5

INMIA 5248 (ATCC948. CCEB 295)									
<i>Bacillus subtilis</i> INMIA 1820 (ATCC 6633)	1	1	1	1	0.5	1	1	1	1
<i>Bacillus cereus</i> INMIA 2111 (ATCC 11778)	30	30	10	10	0.5	30	10	30	30
<i>Bacillus coagulans</i> INMIA 1906 (Bu156. NCIB 8041)	10	10	10	10	0.5	10	10	10	10
<i>Candida albicans</i> INMIA 8013	5	5	30	5	1	5	5	10	10
<i>Kloeckera brevis</i> INMIA 8018	5	1	1	5	1	5	1	10	10
<i>Aspergillus versicolor</i> VKM F-837	10	10	30	10	5	10	10	10	10
<i>Aspergillus flavus</i> INMIA 8134 (VKM F - 747)	10	10	30	10	5	10	10	10	10

Table 7 - The results of combined action of the medicinal agent after the example of a number of susceptible and multiresistant strains of *Mycobacterium tuberculosis*

FS-1 the drug 0.0437 mg/ml	Strains	Concentration of anti-tuberculosis drug							K
		H (µg/ml)		S (µg/ml)		E (µg/ml)		R (µg/ml)	
		1.0	5.0	5.0	10.0	2.0	5.0	40.0	
FS-1	6*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	1*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	7*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	510*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	516*	s	s	s	s	s	s	s	+++

without FS-1		r	r	r	r	r	r	r	+++
FS-1	517*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	518*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	797*	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++
FS-1	H ₃₇ R _v	s	s	s	s	s	s	s	+++
without FS-1		r	r	r	r	r	r	r	+++

Note: R - resistant; S - sensitive; R - Rifampicin; H - Isoniasid; * - multidrug-resistant strain; S – streptomycin; E – ethambutol; +++ confluent growth

Table 8 - Tuberculous lesions in organs of guinea pigs

Group No.	Time after introduction of infection (days)	Time after beginning of treatment (days)	Number of tuberculous lesions in organs	
			Lungs	Liver
Group 1 Control Animals, infected with <i>M. tuberculosis</i> H ₃₇ R _v	39	-	10	12
	46	-	11	15
	53	-	26	31
	55	-	25	34
	59	-	27	40
Group 2 Control animals infected with multiresistant mycobacterium strains	39	-	14	11
	46	-	13	14
	53	-	18	14
	57	-	27	31

	60	-	30	42
Group 3 Test animals infected with <i>M. tuberculosis</i> H ₃₇ R _v and treated with TBD	39	7	17	18
	46	14	11	8
	53	21	9	7
	60	28	3	2
	67	35	-	-
Group 4 Test animals infected with <i>M. tuberculosis</i> H ₃₇ R _v and treated with FS-1	39	7	11	13
	46	14	10	9
	53	21	4	7
	60	28	-	-
	65	33	-	-
Group 5 Test animals infected with <i>M. tuberculosis</i> H ₃₇ R _v and treated with TBD and FS-1	39	7	16	7
	46	14	6	5
	53	21	-	-
	60	28	-	-
	67	35	-	-
Group 6 Test animals infected with multiresistant strains of mycobacteria and treated with TBD	39	7	11	14
	46	14	14	16
	53	21	21	24
	60	28	20	23
	67	35	35	27
Group 7 Test animals infected with multiresistant strains of mycobacteria and treated with FS-1	39	7	12	14
	46	14	10	9
	53	21	4	5
	60	28	2	-
	66	35	-	-
Group 8 Test animals infected with multiresistant strains of mycobacteria and treated with TBD and FS-1	39	7	13	17
	46	14	3	7
	53	21	-	-
	60	28	-	-
	67	35	-	-

Table 9 – Haemagglutinin titre of the residual influenza virus HAU

Exa mpl e №	Compound	Substan ce content, mg/ml	Virus dilutions								Titr., HAU
			1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256	
	1	2	3	4	5	6	7	8	9	10	11
1	ABA-1 (FS-1.1)	5.0	++++	++++	++++	+++	----	----	----	----	12
		2.5	++++	++++	++++	+++	----	----	----	----	12
		1.25	++++	++++	++++	++++	+++	----	----	----	24
2	ABA-2 (FS-1.2)	0.31	++++	++++	++++	++++	++++	----	----	----	32
		0.16	++++	++++	++++	++++	++++	+++	----	----	48

Example №	Compound	Substance content, mg/ml	Virus dilutions								Titr., HAU
			1/2	1/4	1/8	1/16	1/32	1/64	1/128	1/256	
			1	2	3	4	5	6	7	8	
		0.08	++++	++++	++++	++++	++++	++++	++--	----	48
3	ABA -3 (FS-1.3)	2.5	++++	++++	++++	++++	++++	----	----	----	32
		1.25	++++	++++	++++	++++	++++	----	----	----	32
		0.63	++++	++++	++++	++++	++++	++++	++--	----	48
4	ABA -4 (FS-1.4)	5.0	++++	++--	----	----	----	----	----	----	3
		2.5	++++	++--	----	----	----	----	----	----	3
		1.25	++++	++++	++++	++++	++++	+++ +	----	----	64
5	ABA FS-1	0,188	----	----	----	----	----	----	----	----	0
		0,094	++++	++++	----	----	----	----	----	----	4
		0,047	++++	++++	++++	----	----	----	----	----	8
6	ABA -6 (FS-1.5)	0.2	++++	++++	++++	++++	++--	----	----	----	12
		0.1	++++	++++	++++	++++	++--	----	----	----	12
		0.05	++++	++++	++++	++++	++++	++++	++--	----	48
7	ABA -7 (FS-1.6)	0.05	++++	++++	++++	++++	++++	++--	----	----	24
		0.025	++++	++++	++++	++++	++++	++++	++--	----	48
		0.01	++++	++++	++++	++++	++++	++++	++--	----	48
8	ABA -8 (FS-1.7)	0.4	----	----	----	----	----	----	----	----	0
		0.2	----	----	----	----	----	----	----	----	0
		0.1	----	----	----	----	----	----	----	----	0
9	ABA -9 (FS-1.8)	0.06	++++	++++	++++	++++	++++	----	----	----	8
		0.03	++++	++++	++++	++++	++++	----	----	----	16
		0.015	++++	++++	++++	++++	++++	++--	----	----	24
	Virus control		++++	++++	++++	++++	++++	++++	+++ +	++ --	96
	Note: «++++» - 100% «umbrella» hemagglutination «+++» - 75% hemagglutination «++» - 50% hemagglutination «+» - 25% hemagglutination «-» - no hemagglutination										

Table 10 – Determination of FS-1 antiviral activity against influenza virus A/FPV/Waybrige/78/H7N7 in MDCK cell culture after 72 hours

Well number	Active substance content, mg/ml					
	0.038	0.019	0.009	0.005	0 (Cells control)	0 (Virus Control)
1	----*	----	++--	+++-	----	++++
2	----	----	++--	+++-	----	++++
3	----	----	++--	+++-	----	++++
4	----	----	++--	+++-	----	++++
Notes: 1 «*» - CPE manifestation degree 2 «++++» - pronounced degradation of cell monolayer. 3 «----» - no cell degradation.						

Table 11 – Determination of FS-1 antiviral activity against herpes simplex virus of I type, “Victory” strain in RD cell culture after 72 hours

Well number	Active substance content, mg/ml					
	0,038	0,019	0,009	0,005	0 (контроль клеток)	0 (контроль вируса)
1	----*	++++	++++	++++	----	++++
2	----	++++	+++-	++++	----	++++
3	----	+++	+++	++++	----	++++
4	----	++	+++	++++	----	++++
Notes: 1 «*» – CPE manifestation degree 2 «++++» – pronounced degradation of cell monolayer. 3 «----» – no cell degradation.						

Table 12 - FS-1 virucidal effect on human immunodeficiency virus HIV-1 (LAI) (detection in IFA by the protein p24)

Drug	Extinction factor
Virus control (n=6)	2.65517±0.76283
0.188 mg/ml of FS-1 (n=5)	0.04380±0.00086
0.094 mg/ml of FS-1 (n=5)	0.04660±0.000678
0.01 mg/ml of azidothymidine (n=5)	0.04460±0.003187
Cell control (n=5)	0.042±0.000400

Table 13 - FS-1 virucidal effect on human immunodeficiency virus HIV-1 (LAI) (detection in IEA by reverse transcriptase)

Drug	Extinction factor
Virus control (n=5)	2.884±0.043052
0.188 mg/ml of FS-1 (n=5)	0.2274±0.004094
0.094 mg/ml of FS-1 (n=5)	0.7072±0.012464
0.01 mg/ml of azidothymidine (n=5)	0.5724±0.005464
Cell control (n=5)	0.2168±0.000583

Table 14 – Determination of FS-1 antiviral activity *in vitro* against influenza virus A/FPV/Waybrige/78/H7N7 in MDCK cell culture after 72 hours

Well number	Active substance content, mg/ml					
	0.038	0.019	0.009	0.005	0 (Cells control)	0 (Virus Control)
1	----*	----	++--	+++--	----	++++
2	----	----	++--	+++--	----	++++
3	----	----	++--	+++--	----	++++
4	----	----	++--	+++--	----	++++
Notes: 1 «*» - CPE manifestation degree 2 «++++» - pronounced degradation of cell monolayer. 3 «----» – no cell degradation.						

Table 15 - FS-1 preventive effect *in vivo* in a model of influenza virus strain A/FPV/Rostock/34

Drug (dose for 1kg of body weight)	Total number of chickens	Number of survived chickens	Number of chickens that died	Survival %
Saline solution	14	0	14	0
0.290 mg/ml of FS-1	14	14	0	100
1.458 mg/ml of FS-1	14	14	0	100
8.33 mg/ml of Rimantadine	14	4	10	28.6±12,53

Table 16 – FS-1 therapeutic effect *in vivo* in a model of influenza virus strain A/FPV/Rostock/34

Drug (dose for 1kg of body weight)	Total number of chickens	Number of survived chickens	Number of chickens that died	Survival %
Saline solution	14	0	14	0
0.290 mg/ml of FS-1	14	6	8	42.9±13.73
1.458 mg/ml of FS-1	14	14	0	100
8.33 mg/ml of Rimantadine	14	6	8	42.9±13.73

Table 17 – Acute toxicity characteristics (LD50 mg/kg)

Example №	Example	Mice	Rats
	Enteral route of administration		
3	ABA -3 (FS-1.3)	330	243
1	ABA -1 (FS-1.1)	579,25	360,5
5	ABA (FS-1)	n.d.	n.d.
Parenteral route of administration			
3	ABA -3 (FS-1.3)	65	48
1	ABA -1 (FS-1.1)	106	75
5	ABA (FS-1)	213	100

N.d. – not detected

Table 18 – Results of studying FS-1 cumulative toxicity in mice

FS-1 dose (mg/kg)	Number of animals that died	Total number of animals in the group
9.51	0	10
14.27	0	10
21.40	2	10
32.06	6	10
48.13	8	10
72.24	9	10
108.40	10	10

Table 19 – Results of studying ABA FS-1 fetal toxicity

Experimental groups	Dose, mg/kg	Effect (death rate or premature labor)
intramuscularly	100	Prenature labor, unviable fetus
intramuscularly	25	0
intramuscularly	6.25	0

(control)	phosphate buffer	0
per os	100	0
per os	25	0
per os	6.25	0
(control)	phosphate buffer	0

Table 20 – Results of studying FS-1 carcinogenic action

Test	FS-1 “ineffective” concentrations, µg/ml	FS-1 toxic concentrations
SOS Chromotest, <i>E.coli</i>	1-1000	-
Single-strand DNA breaks, RD cells	200-600	1200-2000
Induction of unscheduled (reparative) DNA synthesis, human lymphocytes	50-200	400-800

Table 21 – Structural damage of chromosomes in white blood cells of bone marrow of mice exposed to FS-1

Group	Type of chromosome aberration							N _t (%) M±SD
	N _f		N _{exg} M±SD	N _g M±SD	N _{cb} M±SD	N _M (%) M±SD	N _{CD} (%) M±SD	
	N _{find} M±SD	N _{f_p} M±SD						
Control 1	3.67±1.03	0	0	0	0	0	0	1.33±0.52
Control 2	3.00±0.89	0	0	0	0	0	0	1.67±0.47
Control 3	6.00±1.26	4.17±0.75	2.33±0.52	3.33±1.03	1.83±0.40	5.00±0.63	2.33±0.52	5.50±2.17
Control 4	7.17±1.47	3.67±0.81	3.67±0.52	4.17±0.98	2.67±0.82	3.00±1.09	3.83±0.75	1.67±3.26
8 mg/kg	3.00±1.26	0	0	0	0	0	0	1.83±0.41
22 mg/kg	4.00±0.63	0	0	0	0	0	0	2.17±0.41

Notes: N_f - number of fragments, N_{find} - number of individual fragments, N_{f_p} - number of paired

fragments; N_{exg} - number of exchanges; N_g - number of gaps; N_{cb} - number of breaks in centromere, N_M - number of cells with multiple disorders; N_{CD} - number of cells with complete chromosome destruction; N_t - total number of cells with aberrations.

Table 22 – Structural damages in polychromatic and normochromatic bone marrow erythrocytes of mice exposed to FS-1

Group	$N_{\text{PCE}} (\%)$ M $\pm$ SD	N_{MPCE} M $\pm$ SD	NNCE (%) M $\pm$ SD	N_{MNCE} M $\pm$ SD
Control 1	0.18 $\pm$ 0.08	2.67 $\pm$ 1.37	0.05 $\pm$ 0.05	0.67 $\pm$ 0.82
Control 2	0.25 $\pm$ 0.10	3.17 $\pm$ 0.98	0.07 $\pm$ 0.05	0.83 $\pm$ 0.75
Control 3	4.48 $\pm$ 0.67	93.83 $\pm$ 11.87	0.98 $\pm$ 0.13	21.67 $\pm$ 2.94
Control 4	6.43 $\pm$ 0.80	123.00 $\pm$ 8.51	1.38 $\pm$ 0.15	28.83 $\pm$ 3.19
8 mg/kg	0.30 $\pm$ 0.11	3.50 $\pm$ 1.38	0.07 $\pm$ 0.05	0.83 $\pm$ 0.75
22 mg/kg	0.37 $\pm$ 0.12	4.50 $\pm$ 1.38	0.10 $\pm$ 0.06	1.33 $\pm$ 1.03

Notes: N_{PCE} - number of polychromatic erythrocytes with micronucleous in cytoplasm; N_{MPCE} - number of micronuclei per 1000 of polychromatic erythrocytes; N_{NCE} - number of normochromatic erythrocytes with micronuclei in cytoplasm; N_{MNCE} - number of micronuclei per 1000 of normochromatic erythrocytes.

Table 23 – Study of FS-1 inducing action on the development of dominant lethal mutations in germ cells (sperm cells) of mice

Stage of spermatogenesis	Group	N_o	Npf	F (%)	Ipil M $\pm$ SD
Mature sperm cells	Control 1.1	30	27	90.00	0.06 $\pm$ 0.01
	Control 2.1	30	18	60.00	0.26 $\pm$ 0.01
	Experimental 1.1	30	23	76.67	0.08 $\pm$ 0.02
Late spermatids	Control 1.2	30	25	83.33	0.06 $\pm$ 0.01
	Control 2.2	30	20	66.67	0.15 $\pm$ 0.01
	Experimental 1.2	30	27	90.00	0.07 $\pm$ 0.01
Early spermatids	Control 1.3	30	26	86.67	0.08 $\pm$ 0.01
	Control 2.3	30	23	76.67	0.12 $\pm$ 0.01

	Experimental 1.3	30	27	80.00	0.06±0.01
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Note: N₀ - total number of females; N_{pf} - number of pregnant females; F - fertility; Ipil - postimplantation loss index.

Table 24 – Main characteristics of the subjects

Parameters	Tested drug and dosage groups		
	FS-1 0.1 ml/kg	Placebo 0.1 ml/kg	FS-1 0,125 ml/kg
1	2	3	4
Number of subjects	19	17	19
Mean age (standard deviation)	32.5 ± 8.5	31.24 ± 6.4	34.9 ± 10.9
Gender (males, %; females, %)	78.95 %; 21.05 %	70.59 %; 29.41 %	78.95 %; 21.05 %
Clinical forms (infiltrative, %; fibrocavernous, %)	78.95 %; 21.05 %	70.59 %; 29.41 %	78.95 %; 21.05 %
Process prevalence (single-sided, %; two-sided, %)	55.5 %; 44.5 %	41.2 %; 58.8 %	68.4 %; 31.6 %
Distribution according to the disease duration (less than 1 year, %; more than 1 year, %)	66.70 %; 33.30 %	47.05 %; 52.95 %	42.10 %; 57.89 %

Table 25 – Comparative average statistical APTT rates (s)

Points	1 (primary) group (n=12)	2 (control) group (n=12)	3 (primary) group (n=7)
	M ± m	M ± m	M ± m
Initial	40.15 ± 8.01	43.31 ± 7.10	43.63 ± 4.22
1 month	43.83 ± 4.67	49.08 ± 8.56	29.29 ± 8.24

Table 26 – Comparative average statistical rates of prothrombin index (%)

Points	1 (primary) group (n=12)	2 (control) group (n=12)	3 (primary) group (n=7)
	M ± m	M ± m	M ± m
Initial	81.0 ± 8.77	77.46 ± 8.28	82.13 ± 16.91
1 month	83.17 ± 8.36	87.69 ± 8.02	86.0 ± 13.14

Table 27 – Comparative average statistical rates of thrombin clotting time (s)

Points	1 (primary) group (n=12)	2 (control) group (n=12)	3 (primary) group (n=7)
	M ± m	M ± m	M ± m
Initial	16.1 ± 4.06	16.34 ± 2.44	21.88 ± 5.06
1 month	19.58 ± 1.25	23.46 ± 2.88	24.43 ± 2.08

Note: Statistically significant differences with initial rates:

*- p < 0.05; ** - p < 0.01; ***p < 0.001

Table 28 – Smear conversion dynamics, %

Groups	1 month	2 months	3 months	4 months	5 months	6 months
Group 1	42.3	62.5	63.15*	82.3*	78.6*	77.7*
Group 2	70	47.8	47.6*	88.9*	78.6*	100*
Group 3 (control)	50	58.3	28.5*	53.3*	53.8*	50*

Note: * - p < 0.025; ** - p < 0.001

Table 29 – Comparative data on lack of growth among colonies from sputum in liquid medium, %

Groups	1 month	2 months	3 months	4 months	5 months
Group 1	62.5	55	77.7*	82	100*
Group 2	40	55	81.3*	90*	100*
Group 3 (control)	42.85	61.1	68.7*	80	88.8*

Note: * - p < 0.025; ** - p < 0.001

Table 30 – Comparative data on lack of growth among colonies from sputum in dense medium, %

Groups	1 month	2 months	3 months	4 months
Group 1	69.56	94.7*	100**	100**
Group 2	58.3	84.2*	100**	
Group 3 (control)	63.6	66.6*	75*	70**

Note: * - $p < 0.025$; ** - $p < 0.001$

Table 31 – Comparative data of radiological pattern dynamics

Groups	1 month	2 months	3 months	4 months	5 months	Groups
Group 1	80*	100***	100***	92.9**	92.3**	85.7*
Group 2	92*	95.5***	100***	93.3**	100***	
Group 3 (control)	63.2*	52.4***	53.8***	70**	62.5**	71.4*

Note: * - $p < 0.05$; ** - $p < 0.025$; **** - $p < 0.005$

Table 32 - Comparative average statistical indicators of body weight dynamics within 1 month of therapy

Groups and doses	FS-1, 0.1 ml/kg				FS-1, 0.125 ml/kg				Placebo			
	n	M	±	m	n	M	±	m	n	M	±	m
initial	28	59.04	±	11.23	26	59.40	±	9.95	26	57.85	±	10.37
1 month	21	59.57	±	12.15	19	61.83	±	10.51	19	57.96	±	11.28
2 months	20	61.77	±	11.29	17	57.34	±	11.15	17	57.34	±	11.15
3 months	16	63.1	±	12.05*	15	64.19	±	11.88*	14	54.56	±	8.79
4 months	11	59.89	±	9.33	8	63.57	±	10.72*	10	53.26	±	6.87
5 months	9	62.91	±	9.41		-	-	-	8	54.86	±	7.93

Note: * - $P < 0.05$; ** - $P < 0.01$; *** - $P < 0.001$

Patent Claims

1. Antibacterial agent for treating bacterial infectious diseases including hospital infections and drug resistant tuberculosis (TB), which comprises an ionic nanostructured complex formed by proteins and/or polypeptides, carbohydrates, salts of alkali and alkaline-earth metals and iodine intercalated into them, characterized in that the proteins and/or polypeptides of the ionic nanostructured complex contain at least one chain-terminal amino acid with electron-donor functional groups.
2. Antibacterial agent according to claim 1, characterized in that interleukins are used as proteins, and chain-terminal amino acids are Phe, Ala, Val, Leu, Ile.
3. Antibacterial agent according to claim 1 or claim 2, for use for increasing bacterial susceptibility to antibiotics, including antibiotic-resistant bacteria.
4. Antibacterial agent according to any one of claims 1 to 3, for use for increasing the efficiency of antibiotic treatment for bacterial infectious diseases, including hospital infections and drug-resistant tuberculosis (TB).
5. Antibacterial agent according to any one of claims 1 to 4, for use in antiviral treatment.
6. Antibacterial agent according to any one of the preceding claims, for use for increasing the activity of monocyte-macrophages and cytotoxic T-lymphocytes.
7. Antibacterial agent according to any one of claims 1 to 5, for use for stimulating the hematopoietic function of bone marrow.
8. Antibacterial agent according to any one of claims 1 to 5, for use in antineoplastic treatment.

9. Antibacterial agent according to any one of claims 1 to 5, for use for radioprotective treatment.
10. Antibacterial agent according to any one of claims 1 to 6, characterized in that the ionic nanostructured complex (INSC) has the following formula: $\{ (L_n(MeI_3)^+)_y [Me (L_m)I]^+_x \} (Cl^-)_{y+x+k}$ with $M = 30-300$ kDa.
11. Antibacterial agent according to any one of claims 1 to 5, characterized in that it is presented in a pharmaceutical form suitable for parenteral, oral, external or other application.
12. Antibacterial agent according to any one of claims 1 to 5, characterized in that in certain acceptable concentrations of components it is a non-medicinal agent.
13. Method of producing the antibacterial agent according to claim 1, comprising complexation reaction of carbohydrates and proteins with metal salts, and intercalation of iodine into complex at ionic strength from $5 \cdot 10^{-4}$ to 15 mol/L, characterized in that proteins comprise interleukins and the introduction of interleukins is carried out as an individual stage after iodine intercalation of 5 - 95%.