

## Antibacterial medicines obtained by using the silver nanoparticles

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There is persistent and constantly growing need for new antimicrobials which will be alternative to antibiotics. Wide usage of antibiotics has detected a number of negative factors. First, it is rapid appearance and spread of antibiotic-resistant microorganism strains. Second, it has been found out that antibiotics have a bad influence on microbiocoenosis. Moreover they lead to dysbacteriosis, disturb the intake and uptake of the nutrients, and weaken the immunity. Finally, antibiotics have no effect on viruses. It is possible that virus diseases are widespread nowadays just because of such unreasonably wide usage of antibiotics. According to the World Health Organization (WHO) the viral etiology diseases account for more than 75% of the total number of infectious diseases and the percentage is growing. New dangerous infections appear such as atypical pneumonia, which is caused by coronavirus, bird flu, etc. As a rule the attempts of prompt production of virus vaccines are unsuccessful due to the ability of viruses to mutate and evolve rapidly. Mixed infections have become of great interest, e.g. in case when bacteria become more active in the organism weakened by some virus. The most illustrative case is HIV infection. The high contagiousness of viruses considerably increases the risk of epidemics and pandemics. Besides, rapid development of microbiology and virology, especially of diagnostics, enabled to determine an essential role of infectious agents (e.g. persistent forms) in the etiology of many diseases previously regarded as somatic ones. Viral origin of many oncological diseases has been proved and according to WHO such diseases account for up to 80% of all oncological cases. The direct relation between peptic ulcer and anaerobic bacteria *Helicobacter pylori* has been found out. Many of cardiovascular diseases, which are the principal cause of mortality in the world, also appear due to various infectious agents. For instance, cardiotropic enteroviruses and Cocksackie virus play a considerable role in etiology of rheumatic carditis and non-rheumatic myocarditis. Chlamydia infection negatively contributes to the development of coronary heart disease. In other words, considerable number of illnesses either is caused or accompanied and aggravated by various infection diseases. New approaches and medicines are required for prevention and treatment of such diverse infections and complex infectious-somatic diseases. These medicines are supposed to be different from antibiotics in the way the effect is produced. They should have both antibacterial activity and antiviral one, and also have a general health-improving effect on the organism. In this respect the silver-containing medicines [1] obtained by using the modern nanotechnological achievements seem to be a promising area.

Bactericidal properties of silver and its compounds are well known for a long time. Silver medicines were widely used in 20s-40s of the last century. Being invented more than 100 years ago such medicines as Collargol and Protargol are used in the medical practice even nowadays. Invention of antibiotics reduced the interest in silver-containing medicines; antibiotics became a major concern pretending to be a panacea, but they failed. Meanwhile, chemistry and biochemistry of silver have advanced within last few years; antiviral and fungicidal activities, anti-inflammatory and immunomodulatory effect of silver medicines have been proved. It has led to renewal of interest in silver medicines, especially in their new and improved forms. Taking all this into account we have developed several new methods and techniques of obtaining silver nanoparticles. Bactericidal and antiviral activities of obtained silver nanoparticles have been shown both in vitro and in vivo. Six new silver-containing medicines have been elaborated and certified using these silver nanoparticles. Let us describe their properties briefly.

Medicine “Argovit” is clustered silver (nanosilver) that is a form of colloidal silver with particles of smaller size as compared with traditional colloidal silver medicines. According to the

physicochemical studies (such as electron microscopy, small angle X-ray scattering method, various forms of electron spectroscopy) the average size of initial cluster particles of silver is about 1.5-2 nm for Argovit, and it is much smaller than that is for Collargol and Protargol. As a result efficiency of the medicine increases considerably, moreover it causes the solution aggregative stability. Argovit possesses broad spectrum of antimicrobial activity against various gram-negative and gram-positive bacteria, aerobic and anaerobic bacteria, and also both asporogenic and spore-forming bacteria in the form of monocultures as well as microbial associations, including antibiotic-resistant hospital strains. It shows virucidal and fungicidal activity as well as apparent anti-inflammatory effect. Argovit is certified as a veterinary medical product. It is administered orally in the form of diluted water solution for prevention and treatment of various etiology enteric infections for all species of farm animals, fur-producing animals and poultry regardless of products these animals and poultry produce. In contrast to antibiotics Argovit does not lead to dysbacteriosis; in fact, it facilitates the normalization of organism microbiocenosis. Argovit has been widely clinical tested in such fields of medicine as contaminated surgery, traumatology, combustiology and dermatology. It has proved to be an effective medicine for inhibition of various pyoinflammatory processes in wounds, tissues and on skin [3]. Argovit has appeared to be a good medicine in otorhinolaryngology for treating various infectious and inflammatory diseases of ear, nose and throat; ARD and ARVI [4].

Concentrated cosmetic serum-lotion Argonika is stable aqueous dispersion of silver nanoparticles with small addition of chitosan [5]. It is meant for prevention and treatment of various infectious and inflammatory diseases on the skin and tissues. Argogel gel and Argokrem cream are therapeutic and cosmetic agents. They are produced in a form of dispersion of silver nanoparticles (Argovit) in the gel matrix or cream base correspondingly. Silver particles remain in the nanosize range for these agents [2,5], that sets conditions for high bactericidal and antiviral properties as well as apparent anti-inflammatory effect of these agents. Argogel and Argokrem are meant for usage in treatment and preventive cosmetology and dermatology. These medicines have also been widely clinical tested in contaminated surgery, traumatology, combustiology. As a result they have proved to be effective medicines for inhibition of various pyoinflammatory processes.

Cosmetic preparation "Silver powder" is a therapeutic-and-cosmetic powder based on kaolin, which is modified by immobilization of silver nanoparticles (Argovit) on its surface. Cosmetic preparation SIAL-C is a therapeutic-and-cosmetic powder based on SIAL, which is also modified by Argovit. SIAL is entero- and applicative sorbent of white color. It is obtained by modifying the aluminum oxide with organic silicon compounds. SIAL is fine-dispersed powder with particle size of 5-30  $\mu\text{m}$ ; its surface area consists of mesopores and macropores; the specific surface area is up to 200  $\text{m}^2/\text{g}$ , chemical character of the surface is hydrophilic hydrophobic [6]. Nowadays sorption detoxification finds a wide application in various projects of endoecological rehabilitation of human organism [7,8].

The essence of applicative sorption (vulnerosorption) lies in extraction of microbial cells, bacterial toxins and toxic products of tissue degradation from the surface of affected area. It results in reduction of toxic load on detoxification organs, first of all regional lymph nodes and lymphatic drainage [7]. Additional bactericidal properties of sorbents enhance the therapeutic effect, especially if there is any pathogenic flora in the diseased area.

SIAL-C and "Silver powder" preparations are recommended for use in cosmetology both singly and as a component of cosmetic and medical compositions, applications, masks. Combined effect of silver and adsorptive properties of the matrix results in high efficiency of these preparations. These powders show bactericidal activity as well as anti-inflammatory and tonic effect, stimulate reparative and metabolic processes in the skin. They also promote rapid healing of microtraumas, abrasion and other skin injuries; moreover they have detoxification (cleaning) effect. These powders are recommended for people of all ages for prevention and treatment of skin inflammations, acne

eruptions, intertrigos and other skin defects. They could be used as a part of multimodality therapy for infectious and inflammatory diseases on the skin (e.g. microbial and true eczema, drug-induced toxicodermia, erysipelas, dermatoses of various etiologies, complicated by consecutive infection) [6].

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