Colloidal Nanosilver – a Product of Nanotechnology

Corina SCUTARI[1] Veaceslav GONCIAR[2] Ivan CEKMAN[2,3] Nadejda GORCEACOVA[3,4]
[1]Assistant professor in the department of Pharmacology and clinical pharmacy of State Medical and Pharmaceutical University „N. Testemitanu”
E-mail: doctorscutari@mail.ru, tel. 068687788.
[2]Professor, head of the department of Pharmacology and clinical pharmacy of State Medical and Pharmaceutical University „N. Testemitanu”
[3]„A.A.Bogomoleţ”, Kiev
[4]Professor of the department of Pharmacology and clinical pharmacy of National Medical University

***Abstract* – In a review literary data and results of own investigations of colloidal nanosilver bases are summarized. A wide range of antimicrobial action of silver, the lack of resistance to it, effective against most pathogenic microorganisms, low toxicity, lack of data in the literature about the allergic properties , as well as good tolerability of patients - have contributed to increased interest in silver, in many countries around the world. Colloidal Silver is the safest and most potent natural antiseptic for the human body, that overwhelm over 700 species of pathogens, including staphylococcus, streptococcus, bacteria dysentery, typhoid, etc. It is proved that the water contaminated by high concentrations of bacteria became sterile after one or two hours from the introduction of the silver in amount up to 1 mg/l and maintained for many days. The drug is actively involved into reducing life and termination of pathogen bacteria, viruses, fungi and parasites, stimulate the protective mechanisms of the human body. In this case, it does not affect the benefic microorganisms. Silver by intravenous administration is successfully used for the treatment of septic arthritis, rheumatism, rheumatic endocarditis, rheumatoid arthritis, asthma, influenza, acute respiratory infections, bronchitis, pneumonia, purulent septic diseases, brucellosis, inside - in the treatment of gastritis, gastro-duodenal ulcers, externally - in the treatment of sexually transmitted diseases, septic wounds and burns. The results obtained in different studies on the effect of silver nanoparticles on the organisms are rather contradictory, but to forget about the relevance of this issue is not worth it.**

***Index terms* - antimicrobial activity, colloidal, nanoparticles, nanosilver, silver.**

I. INTRUDUCTION

Nanoparticles of various materials are used everywhere - from paint to food industry. The most "popular" are nanoparticles of silicon oxide, gold, silver, zinc oxide and titanium dioxide [1, 2].

A wide range of antimicrobial action of silver, the lack of resistance to it, efficiency against most pathogenic microorganisms, low toxicity, lack of data in the literature about the allergic properties of silver, as well as good tolerability of patients - have contributed to increased interest in silver, in many countries around the world.

Colloidal nanosilver – a product consisting of silver nanoparticles suspended in water and containing a colloidal stabilizer system (Figure 1). The typical size of silver nanoparticles - 5-50 nm. The fields of application of silver nanoparticles may be different: the spectral-selective coatings for solar energy absorption, as catalysts for chemical reactions, microbial sterilization [2, 7]. The last area of application is the most important and includes the production of various means of packaging, bandages and water-based paints and enamels [3].

Currently, based on some colloidal silver manufactured products – were obtained biologically active additives with antibacterial, antiviral and antifungal activity. However, the impact of silver nanoparticles on the biological effects remains open.

The study of the healing effect of colloidal silver began in the second half of the XIX century after the discovery in 70's years by German gynecologist Charles Creed of antigonorrheal effect of silver nitrate solution of 1% . This discovery allowed to liquidate in Germany hospitals gonorrheal purulent inflammation of the eyes in the newborn. In fact, from that moment began a new century in the study of dangerous bacterial infections prevention [10].

On 23 August 1897 a German surgeon Bennett Creed, continuing his father's research, reported at the XII International Congress of Doctors in Moscow about the broad possibilities of silver preparations application in purulent surgery and some good results of septic infection treatment by the intravenous administration. Then B. Creed and other chemists suggested preparations containing silver in the non-ionized state: in the form of colloidal particles of metallic silver (the drug collargol) and silver oxide solution (protargol), modifications which are used in medicine for more than hundred years. In contrast to previously used silver salts they had no cauterizing effect [5, 6].

In Russia, colloidal silver also was appreciated by doctors who contributed to its increased use in the military field surgery in Russian-Japanese War in 1904. Silver by intravenous administration is successfully used for the treatment of septic arthritis, rheumatism, rheumatic endocarditis, rheumatoid arthritis, asthma, influenza, acute respiratory infections, bronchitis, pneumonia, purulent septic diseases, brucellosi, inside – in the treatment of gastritis, gastro-duodenal ulcers, externally - in the treatment of sexually transmitted diseases, septic wounds and burns [6, 10].

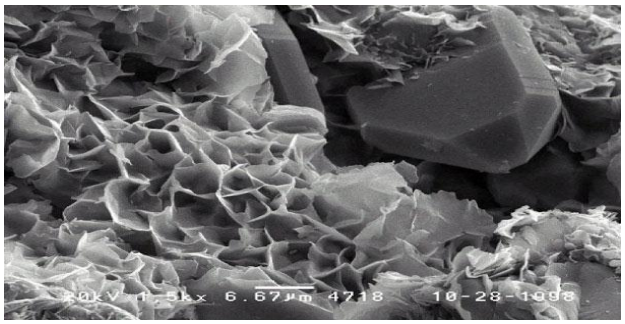

Fig.1. Colloidal nanosilver.

In 1910, the firm "Heiden", summarizing the experience of the practical application of silver in medicine, produced an annotation review of the treatment method of various infections: abscesses, typhoid fever, relapsing fever, inflammation of lungs, sinuses, middle earinfection, gingivitis, gonococcal sepsis, diphtheria toads, dysentery, keratitis, conjunctivitis, leprosy, chancroid, mastitis, meningitis, epilepsy, erysipelas, anthrax, syphilitic ulcers, amyelotrophy, acute articular rheumatism, trachoma, sore throat, boils, cystitis, endocarditis, endometritis, chorea, epididymitis, an ulcer of the cornea [16, 17].

With the discovery of antibiotics and sulfonamides the interest to the drugs of silver declined slightly. But recently, the antimicrobial properties of silver began again to attract attention to itself. This is due to the increase of allergic complications caused by antibiotic therapy, the toxic effects of antibiotics on the internal organs and immune suppression, the emergence of fungal respiratory and dysbiosis after prolonged antibiotic therapy, as well as the emergence of resistant strains of pathogens to antibiotics used [7].

The increased interest in silver has arisen again in connection to the identification of its action in the body as a trace element necessary for normal functioning of organs and systems, immune correcting, as well as powerful antibacterial and antiviral properties [8].

Effectiveness of bactericidal action of colloidal silver due to the ability to suppress the activity of the enzyme which provide oxygen metabolism in protozoa. Therefore, the simplest alien microbes die in the presence of silver ions due to violations of oxygen supply required for their live lihoods [10].

Modern studies of colloidal silver ions showed that they possess a pronounced ability to neutralize vaccinia virus, some strains of influenza virus, enterovirus and adenovirus. In addition, they provide a good therapeutic effect in the treatment of viral enteritis at dogs and swine. At the same time showed the advantage of colloidal silver therapy compared with standard therapy [11, 12].

It was observed beneficial effects of colloidal silver ions on the healing of venous ulcers developing in poor circulation of the lower extremities. In any case, there were no side effects of treatment with silver. Now one of the fastest developing areas of modern nanotechnology - the creation and use of nanoscale particles of different materials. As is known, silver is the most powerful natural antibiotic from all that exists on Earth. It is proved that silver can destroy more than 650 species of bacteria, so it was used by humans for the destruction of various microorganisms for thousands of years, indicating its stable antibiotic effect. Colloidal nanosilver is a product consisting of microscopic silver nanoparticles suspended in demineralized and deionized water. This high technology product is obtained by the electrolytic method [9, 10]. Typical silver nanoparticles have dimensions of 25 nm. They have extremely large specific surface area, which increases the contact area of silver with the bacteria or viruses, greatly improving its bactericidal action. Thus, the use of silver nanoparticles allows hundreds of times lower concentration of silver, while preserving all of bactericidal properties.

Bactericidal agent based on silver nanoparticles is one of the latest achievements of domestic science in the field of nanobiotechnology. The silver's action is not specific for infection (like antibiotics), and on cellular structure. Any cells without a chemically resistant wall (such a cellular structure are bacteria and other organisms without cell walls, for example, extracellular virus) exposed to silver. Since mammalian cells have a membrane completely different type (not containing peptidoglycans), silver in no way affects them. Scientists have observed the silver nanoparticles within the embryos at different developmental stages: development, deformed and dead. According to the results of observations showed that the biocompatibility and toxicity of silver nanoparticles strongly depend on the dose of nanoparticles with a critical concentration of 0.19 nm [9, 16].

Unlike other methods, a separate nanoparticle can be directly mapped in the developing embryos in a nanometer resolution. This method offers new opportunities to study events in real time, leading to abnormalities in the development of embryos.

Physical properties of silver nanoparticles differ from those of the same silver (eg, reducing the size of the particle leads to a decrease in its melting temperature).Technologists have learned to produce nanoparticles of different sizes, shapes and chemical composition. But they do not know how to control the number and the type of defects in the nanoparticles. Therefore, the question of the influence of the nanoparticules defects on its characteristics are unresolved. Meanwhile, it is known that defects can lead to very significant change in the properties of the nanoparticles [14, 15].

Scientists of the University of Maryland (University of Maryland, USA) have developed a technology that allows to produce silver nanoparticles with same size, but are either monocrystalline or contain large numbers of twins - regions with different crystallographic axes orientations. The interface between such areas are a special kind of defects (the so-called defects of twinning). This technology is based on the use of nanoparticles for the synthesis of various polymeric precursors – silvertriphenylphosphine $(PPh_3)_3$3Ag-R with different functional groups (R = Cl or NO_3). If, R = NO3 then from the embryos grow twinned bass and if R = Cl - twin-free (see fig. 2). The formation of silver nanoparticules with a specific feature includes Cl-ions, that block the formation of twins. The average size of nanoparticles was 10.5 nm. Studies have shown that physical and chemical properties of these two types of nanoparticles are significantly different. For example, in interaction with selenium, from the twin-free nanoparticles were prepared hollow nanoparticles Ag_2Se, and from the twinned - solid homogeneous nanoparticles.

This is because the difference of Ag and Se diffusion coefficients in the crystal lattice promotes the formation of vacancies (the accumulation of which eventually forms the cavity inside the NP), whereas the atoms Se, moved not by

the lattice but along the boundaries of twins, easily penetrate these boundaries of Ag, resulting in a homogeneous nanoparticles Ag_2Se. In twinned nanoparticles, the electronic subsystem after the laser pulse is much more rapid cooled (due to the transfer of energy to the lattice). This suggests that the twin boundaries enhance the electron-phonon interaction, which can be adjusted by varying the concentration of defects in the nanoparticles.

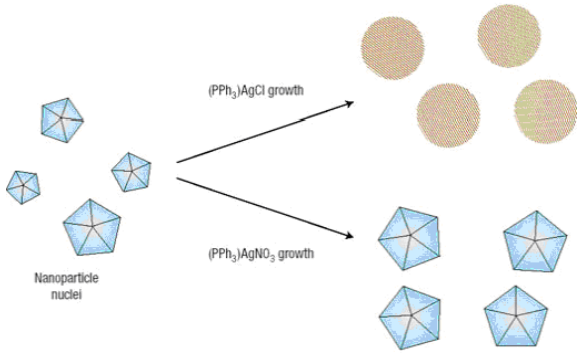

Fig. 2. Growth of twin-free and twinned silver nanoparticles of different precursors.

The Concern "Nanoindustry" from Ukraine has developed technology of silver nanoparticles production, stable in solution and in adsorbed state. The resulting products have a broad spectrum of antimicrobial action. Thus, appeared the opportunity to create a whole range of products with antimicrobial properties with little change of technological process by producers of existing products.

Silver nanoparticles can be used to modify the traditional and creation of new materials, coatings, disinfectants and detergents (including dental and scouring pastes, detergents, soaps), cosmetics. Coatings and materials (composite, textile, paint, carbon and others), modified with silver nanoparticles can be used as a prophylactic antimicrobial protection agents in places where an increasing danger of contamination with infections: in transportation, public catering enterprises, in the agricultural and pastoral areas , children's, sports, and health care institutions. Silver nanoparticles can be used for water purification and destruction of pathogens in the filters of air conditioning systems, swimming pools, showers and other similar places.

Colloidal Silver is the safest and most potent natural antiseptic for the human body, that overwhelm over 700 species of pathogens, including staphylococcus, streptococcus, bacteria dysentery, typhoid, etc. It is proved that the water contaminated by high concentrations of bacteria flexneri (dysentery), Ebert (typhoid fever), staphylococcus, streptococcus, etc., became sterile after one or two hours from the introduction of the silver in amount up to 1 mg/l and maintained for many days [5, 12].

The drug is actively involved into reducing life and termination of pathogen bacteria, viruses, fungi and parasites, stimulate the protective mechanisms of the human body. In this case, it does not affect the benefic microorganisms. At the same time, all bacteria and viruses are killed within 6 minutes of exposure to the colloidal silver. The medical center of the New York University, Department of Orthopedics, were made the study of silver ions action in patients with postoperative infectious complications. From the report of the work: "For 12 out of 14 patients, treatment was successful, and in all 14 treatment led to the undoubted reduction of bacterial flora in the wound, as shown by direct counting of the colony. In no case was shown unwanted effects of treatment with silver. "Silver compounds are used to treat 70% of cases of burns in the USA.

An interesting fact is that more than half of the world's airlines use water treated with silver, as a way to protect the passengers from infections such as dysentery. In many countries, colloidal silver ions are used to disinfect water in swimming pools [11, 12].

Silver, silver ions and silver nanoparticles are generally considered safe enough for people. Nevertheless, recent studies have shown that nanoparticles penetrate into the cells and damage the genotype. There is even reason to believe that silver nanoparticles can actively enter cells by endocytosis. Inside the cell, hydrogen peroxide formed during cell respiration, oxidizes the silver nanoparticles and frees them from the silver ions, thus increasing their toxicity. Consequently, we may even suggest that silver nanoparticles may be cyto- or genotoxic. In addition, it was shown that silver nanoparticles penetrate the skin through pores and glands. If the skin is damaged, it facilitates the penetration of silver particles through the skin.

The data obtained from different studies on the effect of nanoparticles on the organisms are rather contradictory, but to forget about the relevance of this issue is not worth it. Thus, it is important to continue the investigations of silver nanoparticles effect on living organisms and to create methods for detection of nanoparticles in the environment.

REFERENCES

[1] А.В. Бгатов. Биогенная классификация химических элементов// http://www.nisleda.net/…e-bgatov.htm «Философия науки», 2 (6), 1999.

[2] N. Silvestry-Rodriguez, K.R.Bright, D.R.Uhlmann, C.P.Gerba. "Inactivation of Pseudomonas aeruginosa and Aeromonas hydrophila by silver in tap water"//Environmental Science and health, 42 (11), 2007.

[3] Л.А. Кульский. Серебряная вода, Киев, 1987.

[4] Л.В. Григорьева. Водоподготовка и очистка промышленных стоков, Киев, 1973, Вып.10, с. 9–13.

[5] В.С. Брызгунов, В.Н.Липин, В.Р. Матросова. Сравнительная оценка бактерицидных свойств серебряной воды и антибиотиков на чистых культурах микробов и их ассоциациях// Научн.тр.Казанского мед.ин-та, 1964, т.14, с. 121–122.

[6] J.B.Chappel, G.D. Greville. Effect of silver ions on mitochondrial adenosinetriphosphates// Nature (London). 1954, vol.174, p. 930–931.

[7] А.В. Безлепко Кандидат медицинских наук (Главный военный клинический госпиталь имени академика Н. Н. Бурденко) и Гуща И. А. Кандидат медицинских наук (ОАО «ДИОД») Инструкция по медицинскому применению ионного и коллоидного серебра.

[8] Э.Ш.Савадян, В.М.Мельникова, Г.П. Беликова. Современные тенденции использования серебросодержащих антисептиков// Антибиотики и химиотерапия, 1989, N.11, с. 874–878.

[9] R.Doer, W. Zur Bergner. Oligodinamie des Silbers// Biochem. Zeitschr, 1922, N131, p. 351–356.

[10] Мироненко Ю.П. Полостной электрофорез// Медицинская газета, 1971.

[11] А.М.Войтенко Водоподготовка и очистка промышленных стоков. 1973., вып.10., с.128–134.
[12] Лот Таранов, Ирина Филиппова Серебряная вода, Метод Таранова// Диля, 2001 г, с. 25-30
[13] Ю.П.Ульянов, Доктор мед.наук, Зав. Лор-отделением Медицинского Центра «АГАМИ» (Москва) //Проблемы серебряно-зависимых людей.
[14] Е.Родимин. Приготовление целебных медно-серебряных растворов и металлоионотерапия http://www.rem.org.ru/book.htm.
[15] A.R.Shahverdy, Ali Fakhimi, Sara Minaian. Synthesis and effect of silver nanopracles on the antibacterial activity of different antibiotics against Staphylococcus and Escherichia coli// Nanovedicine-Nanotechnology biology and medicine, 3(2): 168–171 Jun 2007.
[16] Eric J. Rentz, DO, MSc Historic Perspectives on Clinical Use and Efficacy of Silver.
[17] Rami Pedahzur, Ovadia Lev, Badri Fattal and Hillel I. Shuval The interaction of silver ions and hydrogen peroxide in the inactivation of E. coli: a preliminary evaluation of a new long acting residual drinking water disinfectant// Water Science and Technology, 1995, Vol 31, No 5–6, p. 123–129 © IWA Publishing 1995.