Research Article

Investigation of the Possibility of Using Silver Nanoparticles Stabilized with Chlorhexidine in Dentistry

Albina Rasulovna Tekeeva[1], Zarina Yakubovna Mengelbaeva[1], Kamilla Valerievna Fidarova[2], Asiyat Daydovna Tohchukova[1], Marat Musadinovich Kardanov[3], Elizaveta Valerievna Dzusova[4] and Sergey Nikolaevich Povetkin[5]*

[1]Department of Oral Medicine, Stavropol State Medical University, Stavropol, Russia; [2]Department of Oral Medicine, Lotus Dent LLC, Moscow, Russia; [3]Department of Dental, Kabardino-Balkarian State University Named after H.M Berbekov, Nalchik, Kabardino-Balkarian Republic, Russia; [4]Department of Oral Medicine, North Ossetian State Medical Academy, Vladikavkaz, Republic of North Ossetia, Russia; [5]Department of Medicine, North Caucasus Federal University, Stavropol, Russia

Corresponding author:
Sergey Nikolaevich, Department of Medicine, North Caucasus Federal University,
Stavropol, Russia,
E-mail: ruslankalmykov777@yandex.ru

Abstract

Nanotechnologies are applicable to any branches of dentistry: Radiography, orthodontics, surgery and therapy. Due to the tiny size of the nanoparticles, they are able to easily penetrate and fill tissues and fight pathogens.

Today, many studies are being conducted simultaneously, considering various ways of using nanoparticles for different dental purposes. In this article, the possibility of using silver nanoparticles stabilized with chlorhexidine in dentistry is studied. It is concluded that the stabilization of nanoparticles with chlorhexidine is one of the most promising methods that can be introduced into clinical practice in the near future.

Keywords: Nanoparticles; Dentistry; Nanosilver; Chlorhexidine

Introduction

Today, the issue of finding fundamentally new medicines with high antibacterial activity that would significantly reduce the use of antibiotics in the practice of a doctor and thereby reduce the further spread of antibiotic resistance is extremely urgent. [1,2]

Currently, a wide range of antibiotics are used in dentistry and maxillofacial surgery, which are part of the materials for the local treatment of odontogenic infectious diseases. [3-5] However, the activity of antibacterial components in the composition of these drugs is short-term. In addition, it was not possible to give resistant antibacterial properties to cements, composites and adhesives. The use of light-cured composite materials of the latest generation does not guarantee further protection of the hard tissues of the tooth from the occurrence of secondary (recurrent) caries. [6,7] For this reason, studies related to the prospects of using colloidal solutions of metal nanoparticles as an antibacterial component in the composition of restoration materials are relevant. [8-11] The high pH level of the oral fluid, a wide variety of biochemical processes, the presence of a wide range of natural and pathogenic microorganisms of the oral cavity, the features of the structure and chemical composition of tooth tissues-all this dictates the following requirements for filling materials and adhesive systems:

1. A wide range of bactericidal action.

2. Prolonged bactericidal action.

3. No local and systemic toxic effects.

4. Adhesion to hard tooth tissues and surfaces of orthopedic structures.

5. Insolubility in oral fluid.

6. Preservation of physical and chemical properties when interacting with other dental materials.

Recently, the possibilities of using nanopreparations in medicine have been studied. The bactericidal activity of silver nanoparticles for various individual strains of microorganisms has been studied quite well. [12-15] From a practical point of view, it is necessary to study the antimicrobial properties of aqueous dispersions of silver and other metals directly with the microflora of plaque.

There are a number of works [16-19] in which nanoparticles are stabilized by bactericidal substances, which enhances their bactericidal effect. In accordance with this, it was proposed in this work to develop a technology for stabilizing Ag nanoparticles with chlorhexidine.

Materials and Methods

As a synthesis, chemical reduction in an aqueous medium was chosen as the simplest and most accessible. [20,21] As a result of the analysis of the literature data, a method for the synthesis and stabilization of silver nanoparticles was developed, which consists of the following main stages:

1. Preparation of a solution of chlorhexidine bigluconate $C_{22}H_{30}Cl_2N_{10}$;

2. Dissolution of $AgNO_3$ silver nitrate in distilled water;

3. Preparation of a solution of sodium borohydride NaBH4;

How to Cite this Article: Tekeeva AR, et al. Investigation of the Possibility of Using Silver Nanoparticles Stabilized with Chlorhexidine in Dentistry. Ann Med Health Sci Res. 2021;11:S3:39-45.

4. Connection of the obtained solutions;

5. Formation of Ag silver nanoparticles;

It is worth noting that the synthesis process takes place according to the following scheme:

$AgNO_3$+(reducing agent) → Ag NPs

At the first stage, 5 ml of chlorhexidine bigluconate 20% $C_{22}H_{30}Cl_2N_{10}$ was measured using universal graduated pipettes and transferred to a beaker. Then 5 ml of distilled water was added to the glass, the resulting mixture was left to mix.

At the second stage, 0.0048 grams of silver nitric acid $AgNO_3$ were weighed on analytical scales and transferred to a beaker and 1 ml of distilled water was added.

At the third stage, the resulting solution of silver nitrate was poured drop by drop with a Mohr pipette with intensive stirring to a solution of chlorhexidine bigluconate.

At the same time, no changes in the color and consistency of the solution were observed.

At the fourth stage, 0.0063 grams of sodium borohydride $NaBH_4$ was weighed on an analytical balance, quantitatively transferred to a beaker and 100 ml of distilled water was added.

At the fifth stage, the resulting mixture was added 20 drops to a solution of silver and chlorhexidine with intensive stirring using a Mora pipette.

As a result, the following scheme of the chemical reaction is assumed:

$2AgNO_3+2NaBH_4+6H_2O \rightarrow 2Ag+7H_2\uparrow+2NaNO_3+2H_3BO_3$

A gradual staining of the solution in amber color was observed, the resulting mixture was left to mix for 10 minutes until the components were completely dissolved.

Two methods were also proposed to study the effect of the speed and sequence of adding components. According to the first method, the sequence of adding solutions is shown in Figure 1.

Whereas according to the second method, presented in Figure 2.

In both methods, the addition rates of silver nitrate were 3.6 l/h, and sodium borohydride 3.6 l/h and 0.18 l/h, respectively. The rate of addition of solutions was regulated by means of a peristaltic pump installed in a glass reactor Ready.

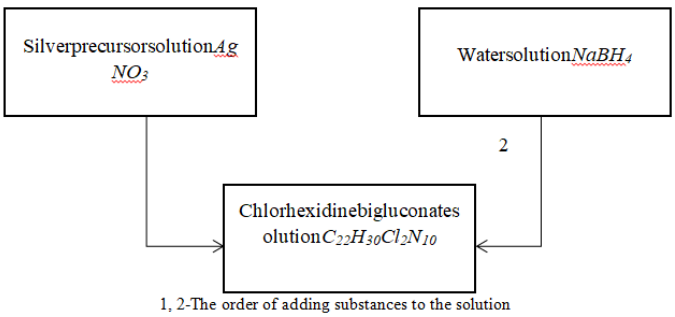


Figure 1: The sequence of adding solutions according to the method of synthesis of AgNPs#1.

Results and Discussion

The resulting sol of silver nanoparticles was studied using a photocor complex photon correlation spectrometer. As a result, a histogram and a correlation function for measuring the size of silver particles were obtained, shown in Figures 3 and 4.

As can be seen from the distribution histogram in Figure 3, all particles have an average radius of 75 nm. The largest number of silver particles in the ash have a radius of about 80 nm, the rest are distributed in the range from 30 nm to 100 nm.

The optical density of silver nanoparticles was measured using the SF-56 spectrophotometer. As a result, the absorption spectrum in the UV and visible regions of the spectrum was obtained, shown in Figure 5.

The absorption spectrum has a band with an absorption maximum at 440 nm, the presence of which is due to the surface plasmon resonance of silver nanoparticles. [11]

The phase composition of the colloidal silver preparation was studied using a PAN anytical Empyrean X-ray diffractometer. Before the measurement, the sample was ground in a mortar with aerosol to a homogeneous state. As a result of X-ray phase analysis, a diffractogram was obtained, shown in Figure 6.

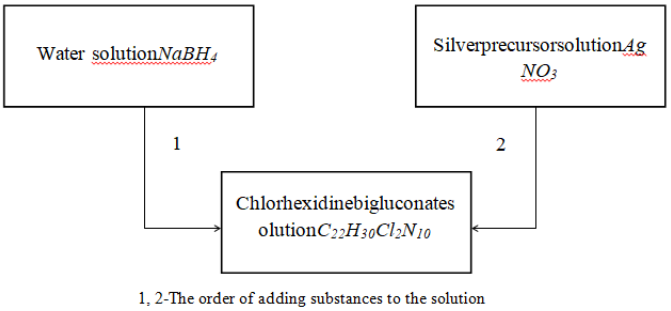


Figure 2: The sequence of adding solutions according to the method of synthesis of AgNPs#2.

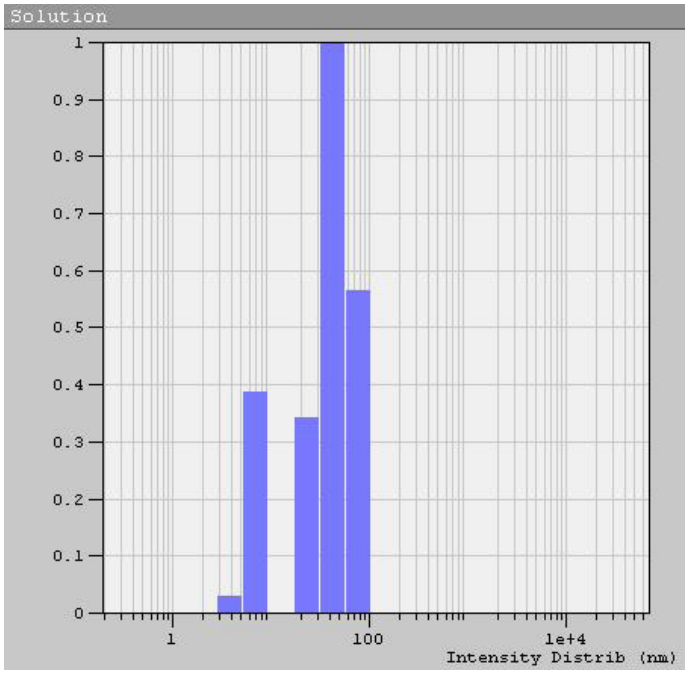


Figure 3: Histogram of the distribution of hydrodynamic radii of silver nanoparticles.

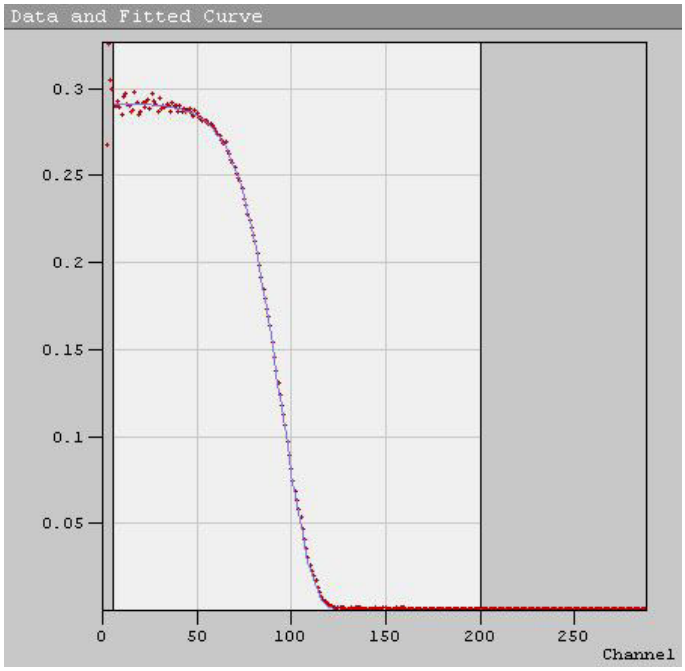


Figure 4: Correlation function of measuring the size of silver particles.

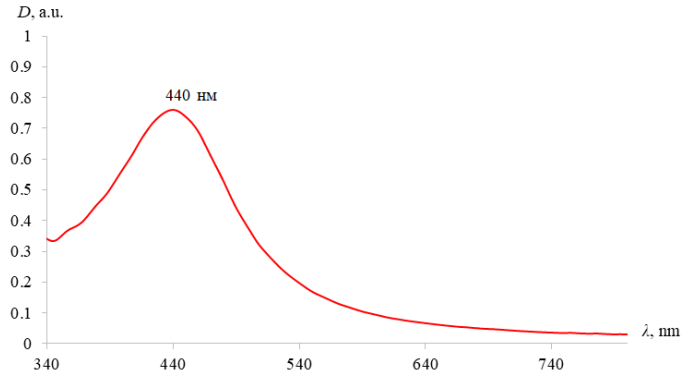


Figure 5: Absorption spectrum of Ag nanoparticles stabilized with chlorhexidine.

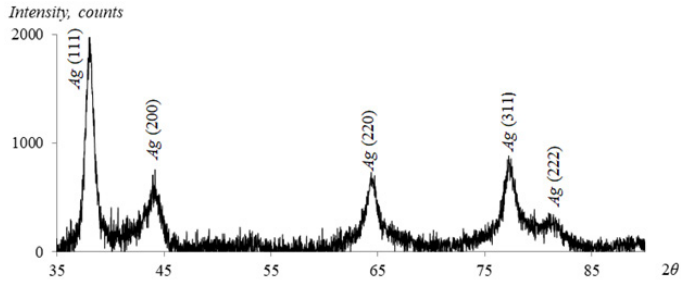


Figure 6: Diffract gram of silver nanoparticles.

The obtained peaks correspond to silver nanoparticles with a face-centered cubic (HCC) crystal lattice. The crystallographic plane (111) prevails, and there are also phases with Miller indices (311), (200), (220), (222). Theinterpretation of the diffractogram showed that the silver nanoparticles have a cubic face-centered crystal lattice, the space group Fm-3m. The HCC models of the silver crystal lattice are shown in Figure 7.

As a result of the study of sols of silver nanoparticles obtained by methods 1 and 2 on the *SF-56* spectrophotometer device, the absorption spectra in the UV and visible spectral regions were obtained, shown in Figures 8 and 9.

The sol data were also studied using a Photocor Complex photon correlation spectrometer. As a result, the histograms shown in Figures 10-13 were obtained.

Analyzing the obtained data, we can say that in all four samples there is a band on the absorption spectra with an absorption maximum at 440 nm. [22] By changing the intensity of the peak, it is possible to judge the change in the concentration of nanoparticles. The higher the absorption maximum, the greater the concentration of particles and vice versa. [23] Also, analyzing the obtained histograms, we can conclude that according to method 1, the average diameter and spread of the particles of the obtained nanoscale silver is less than according to method 2. As a result of the conducted studies, it was found that the

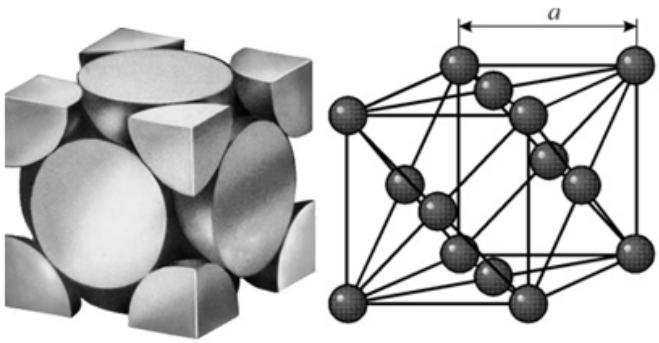


Figure 7: HCC models of the silver crystal lattice.

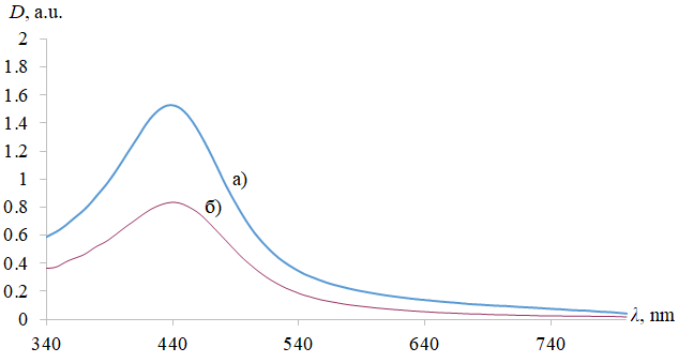


Figure 8: Absorption spectrum of Ag nanoparticles stabilized with chlorhexidine according to method 1.

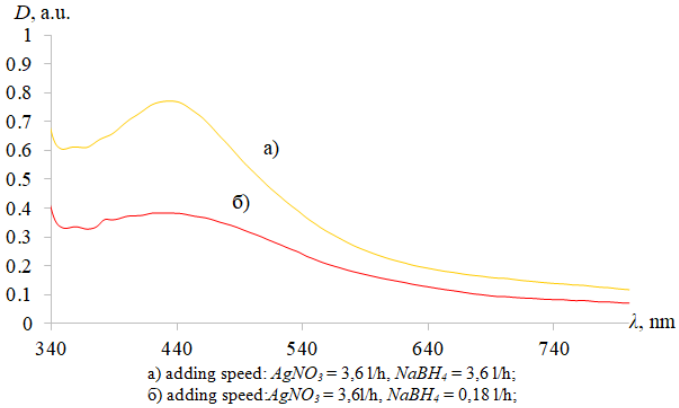


Figure 9: Absorption spectrum of Ag nanoparticles stabilized with chlorhexidine according to method 2.

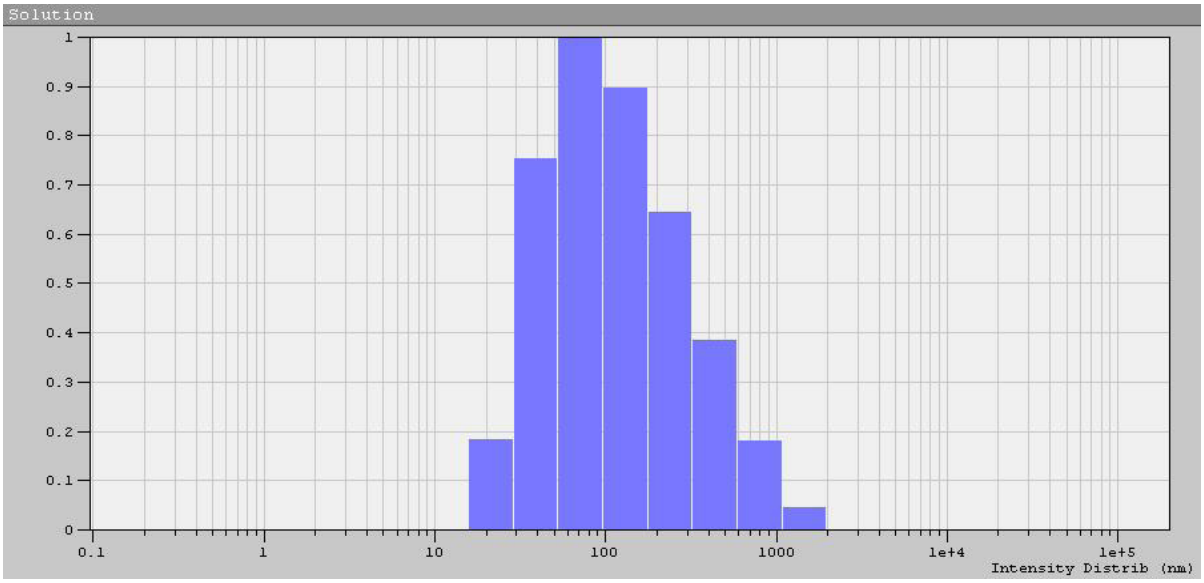


Figure 10: Histogram of the distribution of hydrodynamic radii of nanoscale silver obtained by the 1a method.

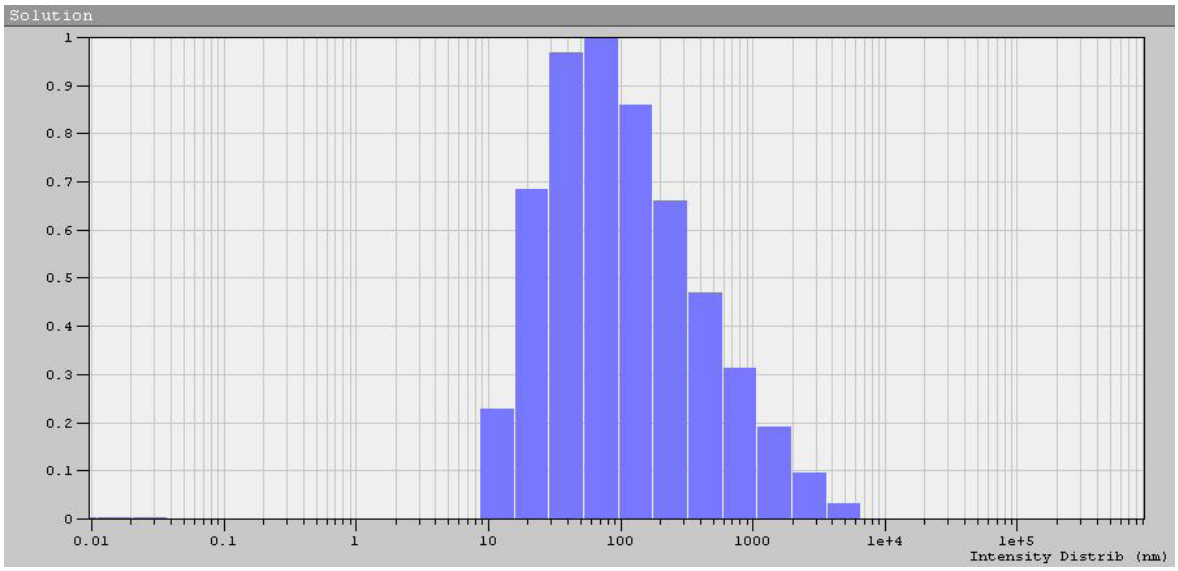


Figure 11: Histogram of the distribution of hydrodynamic radii of nanoscale silver obtained by the 1b method.

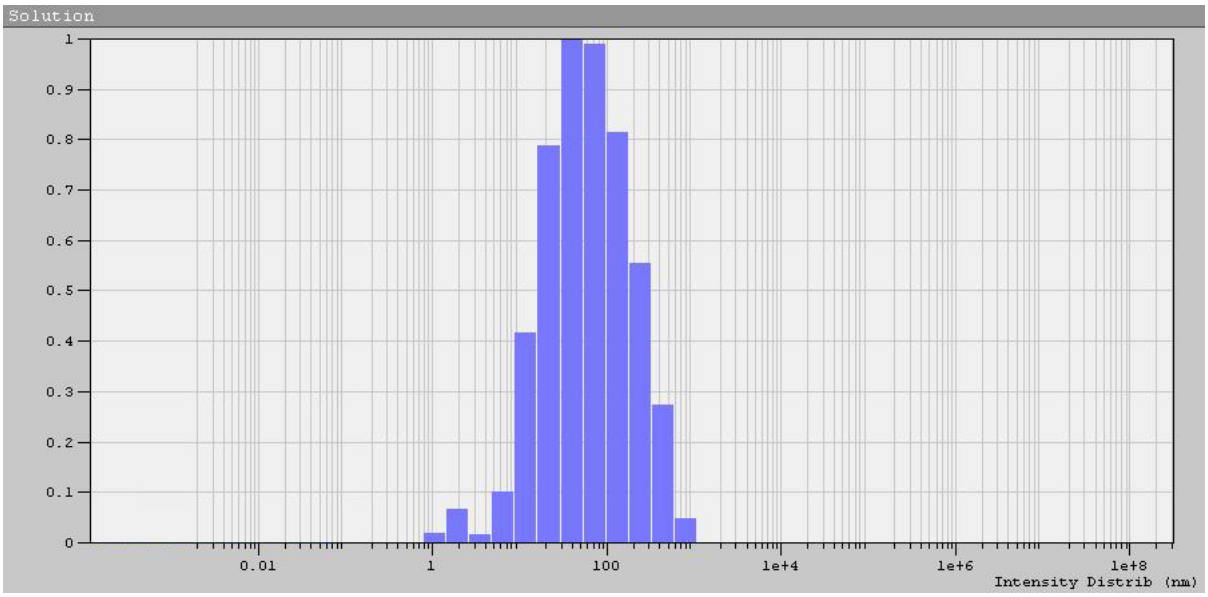


Figure 12: Histogram of the distribution of hydrodynamic radii of nanoscale silver obtained by the 2a method.

experiments performed according to method 1 were the most effective, since the concentration of nanoparticles is higher than in the experiments performed according to method 2. It is also worth noting the change in the concentration of silver nanoparticles with varying rates of addition of solutions: with an increase in the rate of addition of sodium borohydride according to method 1, the concentration of nanoscale silver decreases, and in the second case, on the contrary, the concentration is higher with a high rate of addition of $NaBH_4$.

The effect of changes in the concentration of Ag and $C_{22}H_{30}Cl_2N_{10}$ on the concentration of the obtained nanoparticles was also considered. The data obtained on the spectrophotometer are shown in Figures 14 and 15.

Thus, after studying the data obtained, we can say that the most optimal method for the synthesis of silver nanoparticles is the borohydride method using chlorhexidine $C_{22}H_{30}Cl_2N_{10}$ as a stabilizer. And the most effective is the method of synthesis 1, with the slow addition of sodium borohydride.

Based on studies using the Photocor Complex photon correlation spectrometer, silver particles have an average radius of about 75 nm. Silver particles have a positive charge, the ζ-potential is +25 mV.

When measuring the optical density of sol on a spectrophotometer

The maximum absorption of SF-56 was observed at 430 nm, which corresponds to the plasmon resonance of silver

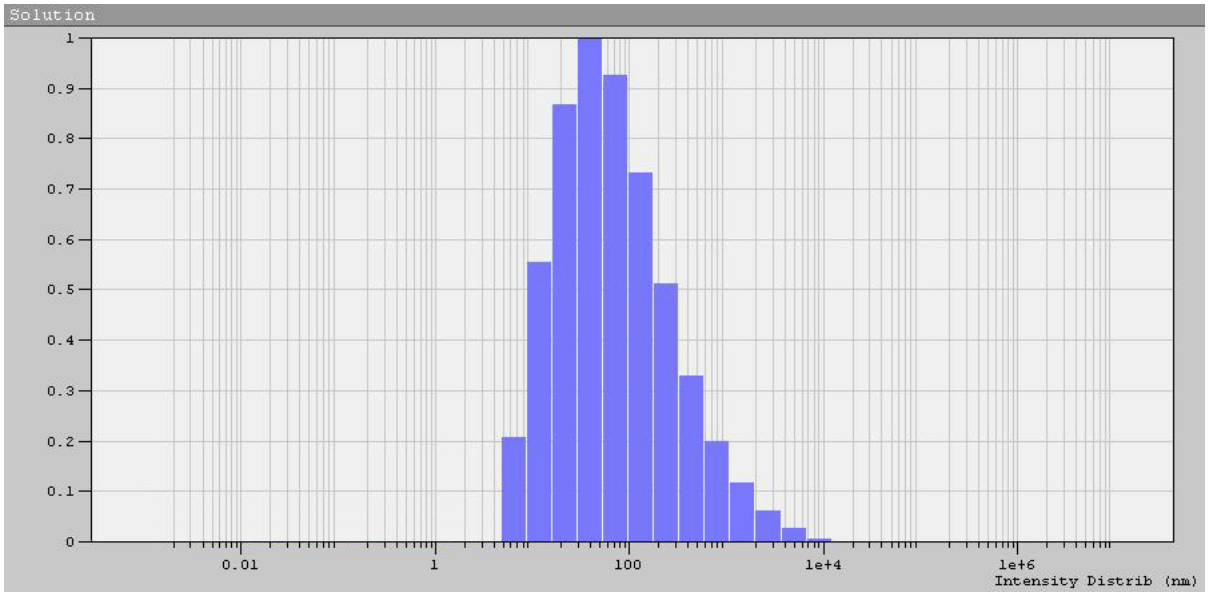
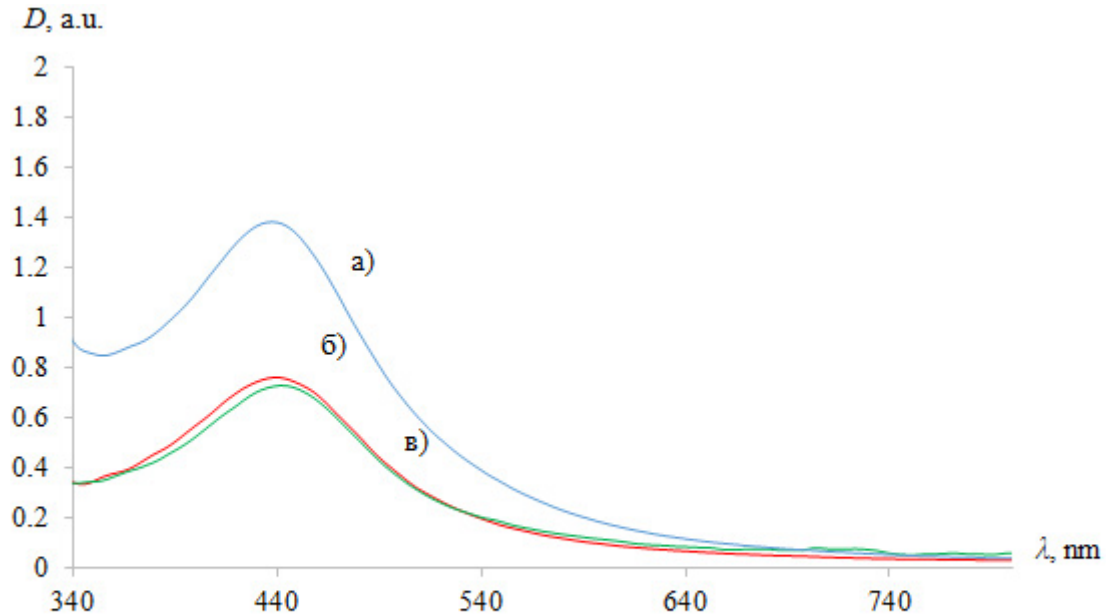


Figure 13: Histogram of the distribution of hydrodynamic radii of nanoscale silver obtained by the 2b method.



а) AgNPs concentration =0,14 г/л; б) AgNPs concentration = 0,28 г/л; в) AgNPs concentration =0,56 г/л

Figure 14: Absorption spectrum of Ag NPs.

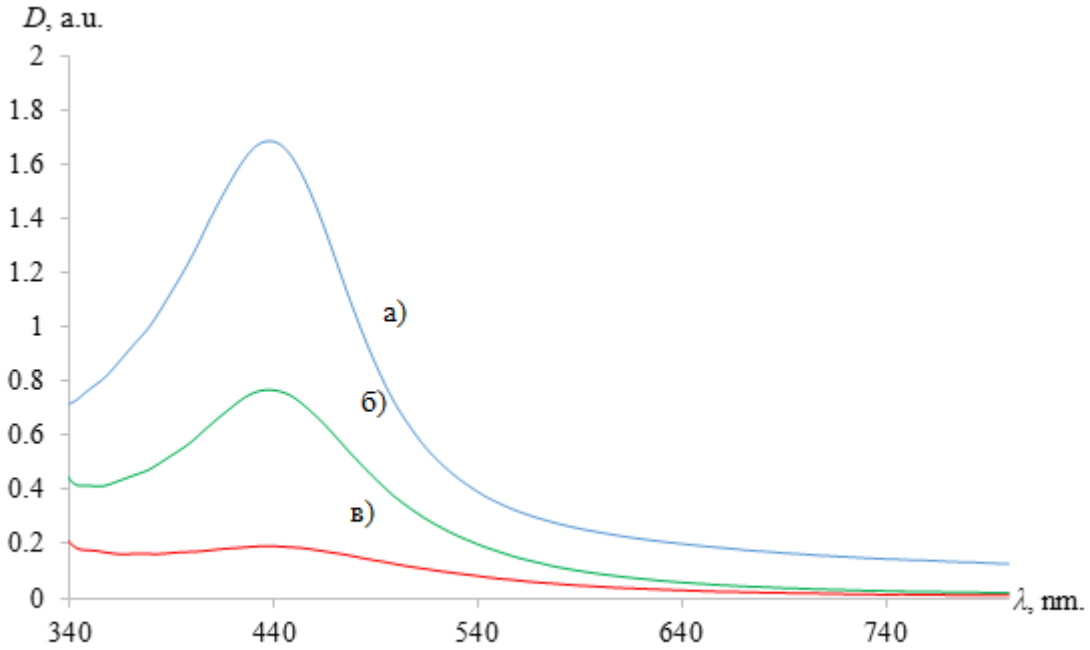


Figure 15: Absorption spectrum of Ag nanoparticles.

nanoparticles.

The results are confirmed by the analysis of the X-ray image, from which it follows that the obtained peaks correspond to silver nanoparticles with a face-centered cubic crystal lattice. [24-26]

Conclusion

According to the results of our studies, it can be argued that the obtained colloidal solutions of silver nanoparticles stabilized with chlorhexidine can become a good alternative to antibacterial drugs in the treatment of local infectious processes.

In dentistry, it is possible to use these colloidal solutions as an antibacterial component of composite filling materials, adhesive systems and etching gels, as well as sillers and temporary filling materials, which will improve the results of treatment and prevention of caries and its complications.

References

1. Lopteva MS, Tekeeva AR, Pushkin SV, Nagdalian A, Kolesnikov V, Marinapetrovna M, et al. 5% Suspension of albendazole echinacea magenta (echinacea purpurea) toxicometric evaluation. Entomol Appl Sci Lett. 2018;5:30-34.
2. Mishununa VV, Chapanov MM, Gakaeva KI, Tsoroeva MB, Kazanova SA, Gorlova MI, et al. Computed quantum chemical modeling of the effect of nanosilver on coronavirus covid-19. Pharmacophore. 2021;12:14-21.
3. Razin MP, Minaev SV, Axelrov MA, Tarakanov VA, Svirsky AA, Trushin PV, et al. Diagnosis and treatment of the congenital diaphragmatic hernia in children: A multicenter research. Medi News North Cauc. 2019;14:302-308.
4. Minaev SV, Kirgizov IV, Akselrov MA, Gerasimenko IN, Shamsiev JA, Bykov NI, et al. Efficiency of retrieval bags for use during laparoscopic surgery to remove hydatid cysts of the liver. Medi News North Cauc. 2019;14:461-465.
5. Nagdalian AA, Selimov MA, Topchii MV, Oboturova NP, Gatina YS, Demchenkov EL. Ways to reduce the oxidative activity of raw meat after a treatment by pulsed discharge technology. Res J Pharm Biol Chem Sci. 2016;7:1927-1932.
6. Kotsoeva GA, Esiev RK, Toboev GV, Zakaeva RS, Kulova AA, Tsokova LV, et al. Phytoadaptogenic cocktail use "biorithm-e" in the complex treatment of odontogenic inflammatory diseases of the maxillofacial region. Ann Dent Spec. 2021;9:52-57.
7. Bledzhyants GA, Mishvelov AE, Nuzhnaya KV, Anfinogenova OI, Isakova JA, Melkonyan R S. The effectiveness of the medical decision-making support system "electronic clinical pharmacologist" in the management of patients therapeutic profile. Pharmacophore. 2019;10:76-81.
8. Blinov AV, Kravtsov AA, Krandievskii SO, Timchenko VP, Gvozdenko AA, Blinova AA. Synthesis of MnO2 nanoparticles stabilized by methionine. Russ J Gen Chem. 2020;90:283-286.
9. Blinov AV, Maglakelidze DG, Kravtsov AA, Blinova AA, Gvozdenko AA, Golik AB, et al. Influence of active acidity of the medium on the stability of MnO2 nanoparticles. PCASCNN. 2020;12:33-41.
10. Blinov AV, Yasnaya MA, Blinova AA, Shevchenko IM, Momot EV, Gvozdenko AA, et al. Computer quantum-chemical simulation of polymeric stabilization of silver nanoparticles PCASCNN. 2019;11:414-421.
11. Barabanov PV, Gerasimov AV, Blinov AV, Kravtsov AA, Kravtsov VA. Influence of nano silver on the efficiency of Pisumsativum crops germination. Ecotoxicol Environ Saf. 2018;147:715-719.
12. Lunin LS, Lunina ML, Kravtsov AA, Sysoev IA, Blinov AV, Pashchenko AS. Effect of the Ag nanoparticle concentration in

TiO2–Ag functional coatings on the characteristics of GaInP/GaAs/Ge photoconverters. Semiconductors. 2018;52:993-996.

13. Blinov AV, Kravtsov AA, Bondarenko EA, Bondarenko SA. Study of the influence of the type of the alcohol environment on the structure of nanoscale Zinc Oxide. Int J Pharm Technol. 2016;8:27129-27135.
14. Blinov AV, Kravtsov AA, Raffa VV, Kramarenko VN, Krandievsky SO, Maglakelidze DG, et al. Influence of synthesis conditions on aggregative stability of Ag alcosols. PCASCNN. 2020;12:25-32.
15. Blinov AV, Gvozdenko AA, Yasnaya MA, Golik AB, Blinova AA, Shevchenko IM, et al. Effect of synthesis parameters on dimensional characteristics of fe3o4 nanoparticles: Neural-network research. PCASCNN. 2019;11:298-306.
16. Yasnaya MA, Blinov AV, Blinova AA, Shevchenko IM, Maglakelidze DG, Senkova AO. Determination of optimal modes for measuring the size of colloidal particles by photon-correlation spectroscopy and acoustic spectroscopy. PCASCNN. 2020;12:232-242.
17. Demchenkov EL, Nagdalian AA, Budkevich RO, Oboturova NP, Okolelova AI. Usage of atomic force microscopy for detection of the damaging effect of CdCl2 on red blood cells membrane. Ecotoxicol Environ Saf. 2021;208:1-7.
18. Blinov AV, Gvozdenko AA, Kravtsov AA, Krandievsky SO, Blinova AA, Maglakelidze DG, et al. Synthesis of nanosized manganese methahydroxide stabilized by cysteine. Mater Chem Phys 2021;2651.
19. Blinov AV, Gvozdenko AA, Yasnaya MA, BlinovassAA, Kravtsov AA, Krandievsky SO, et al. Synthesing and studying the structure of nanoscale copper (II) oxide stabilized by polyethylene glycol. Her Bauman Mosc State Tech Univ Ser Nat Sci. 2020;90:56-70.
20. Blinov AV, Siddiqui SA, Nagdalian AA, Blinova AA, Gvozdenko AA, Raffa VV, et al. Investigation of the influence of Zinc-containing compounds on the components of the colloidal phase of milk. Arab J Chem. 2021;14:1-15.
21. Salins SS, Siddiqui SA, Reddy SVK, Kumar S. Parametric analysis for varying packing materials and water temperatures in a humidifier. 2020.
22. Siddiqui SA, Ahmad A, Siddiqui AA, Chaturvedi P. Stability analysis of a cantilever structure using ANSYS and MATLAB. 2021.
23. Nagdalian AA, Rzhepakovsky IV, Siddiqui SA, Piskov SI, Oboturova NP, Timchenko LD, et al. Analysis of the content of mechanically separated poultry meat in sausage using computing microtomography. J Food Compos Anal. 2021;100.
24. Raevskaya AI, Belyalova AA, Shevchenko PP, Karpov SM, Mishvelov AE, Simonov AN, et al. Cognitive impairments in a range of somatic diseases diagnostics, modern approach to therapy. Pharmacophore. 2020;11:136-41.
25. Galabueva AI, Biragova AK, Kotsoyeva GA, Borukayeva ZK, Yesiev RK, Dzgoeva ZG, et al. Optimization of Modern Methods of Treating Chronic Generalized Periodontitis of Mild Severity. Pharmacophore. 2020;11:47-51.
26. Remizova AA, Dzgoeva MG, Tingaeva YI, Hubulov SA, Gutnov VM, Bitarov PA, et al. Tissue dental status and features of periodontal microcirculation in patients with new covid-19 coronavirus infection. Pharmacophore. 2021;12:6-13.