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Development of Treatment and Prophylactic Means with Selenium Nanoparticles on the Basis of Mineral Water of the Krasnoarmeysk Source for Application in Balneology

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***Abstract*—The purpose of the study is development technology of receiving mineral waters with nanoparticles of selenium and studying of their stability. The studied samples — the concentrated solution of nanoparticles of selenium contens selenium about 1,4 mg/ml, mineral water of the Krasnoarmeysky source. The expediency, reliability and informational content of a method of photon correlation spectroscopy are shown for assessment of changes in system mineral water – nanoparticles on a nanolevel. Results of researches on studying of aggregate stability of nanoparticles of selenium with a hydrodynamic radius – 37,5-38 nanometers by mixing with mineral water of the Red Army source are presented in article. The stability of the mixtures was evaluated by the size of dispersed particles. In particular stability of particles directly after mixing and under the influence of various physical factors – ultrasonic radiation, an exposition by direct sunlight, the lowered temperature and room temperature is studied. After of storage, the parameters of each of the solutions were studied. As a result of the conducted research the conclusion is drawn that the sample has the maximum stability which prepared by simple mixing at the same time at storage him at the lowered temperature of a particle have the smallest diameter and least are exposed to stratification on fraction.**

Keywords—nanoselenium, mineral water of the Krasnoarmeysky source, method of photon correlation spectroscopy, stability of nanoparticles, aggregate stability

I. Introduction

Among all registered diseases in the Russian Federation, skin diseases account for 3.9%, and among diseases with a diagnosis established for the first time in their life, this indicator reaches 6.1% [1-3]. The most common dermatological diseases are: eczema (31%), acute skin diseases (29%), psoriasis (22.5%) [4] and other chronic dermatoses (17.5%) [5, 6]. Dermatitis is an inflammatory skin disease caused by irritating or sensitizing effects of external factors. Scientifically based balneology attaches great importance to the use of medicinal mineral waters in the practice of treating skin diseases [7]. Balneotherapy is a well-known system of healing the body, based on the external use of natural and artificially prepared mineral waters, most often in the form of baths [8-12]. Also, for the treatment of skin diseases are used antioxidant agents [13]. One of the most powerful natural antioxidants is the essential trace element selenium. Selenium as a non-specific immunomodulator has a good therapeutic effect in atopic dermatitis. Lack of selenium causes peeling of the epidermis, yellowness of the skin, nail damage and hair loss [14-16]. Currently, there is one of the types of treatment - "selenium baths", shown in eczema, dermatitis, pyoderma, scaly deprive, acne. Taking selenium baths improves the metabolic processes in the skin, promotes the removal of toxins from the body, and has an immunomodulatory effect [17].

The purpose of the study was to develop a technology for producing mineral waters with selenium nanoparticles and to study their stability.

II. Experimental

Samples under study: a concentrated aqueous solution of nanoparticles of zero-valent selenium (Se0), selenium content: 1.4 mg/ml. Selenium nanoparticles were obtained by A.V. Serov on the basis of the nanocenter of the North Caucasus Federal University (Stavropol). By chemical composition, the mineral water of Krasnoarmeysky spring in Pyatigorsk belongs to carbonate waters and has an average degree of mineralization (5 g/l). Used equipment. The solutions were prepared using a US-2200D top-wheel mixer (JSC NPO Tekhnokom, Russia) in the laboratory of the Pyatigorsk Medical and Pharmaceutical Institute (Pyatigorsk). The obtained solutions were analyzed by photon correlation spectroscopy on a Photocor Complex installation (Antek-97 LLC, Russia), computer processing of spectroscopy results was performed using DynaLS software on the basis of the North Caucasus Federal University (Stavropol).

The determination of the morphology of selenium nanoparticles was performed by electron microscopy using a JEOL transmission electron microscope JEM 100B. When conducting electron microscopic studies on a transmission electron microscope, it is necessary to dilute the selenium nanoparticles concentrate to a weak opalescence, then apply it to a carbon-coated measuring grid. After the preparation dries, the grid was placed on the table of the electron microscope and studies were performed.

III. Results and discussion

Used in the study, the preparation of nanoscale selenium was obtained by reduction in the aqueous medium of selenium-containing precursor (selenous acid) with ascorbic acid in the presence of a stabilizer, polyvinylpyrrolidone. The distribution of selenium nanoparticles by size was determined from the images in micrographs obtained as a result of analysis of variance. This distribution was then shown in graphical form to further identify its patterns. In Fig. 1 presents the results of transmission electron microscopy of the preparation applied (TEM-image of selenium nanoparticles).

Analysis of the figure showed that selenium nanoparticles have a spherical shape with low polydispersity and an average diameter of about 35 nm. Particles do not have a pronounced crystalline nucleus.

During aggregation, gluing only the nanoparticle shell consisting of a soluble polymer is observed, due to which it is possible to sublimate the drug into the solid phase and transfer it back to an aqueous solution, while maintaining the original particle size distribution. For storage and transportation, as well as the stability of the developed product, this property is of great importance. The molecular structure deposited, stabilized by polyvinylpyrrolidone, remains uncertain.

Probably, selenium nanoparticles have the form of supramolecular complexes (compounds of the receptor-substrate type). The receptors are molecules of hydrated polyvinylpyrrolidone. Substrate are elemental selenium molecules that bind multiple polymer chains. It can be assumed that part of the concentrate of nanoparticles of zero-valent selenium, elemental selenium is dispersed to the level of molecules and / or molecular nanoclusters, which is also shown in research Miroshnichenko M.V. [18, 19]. This steady state of elemental selenium ensures its high biological activity.

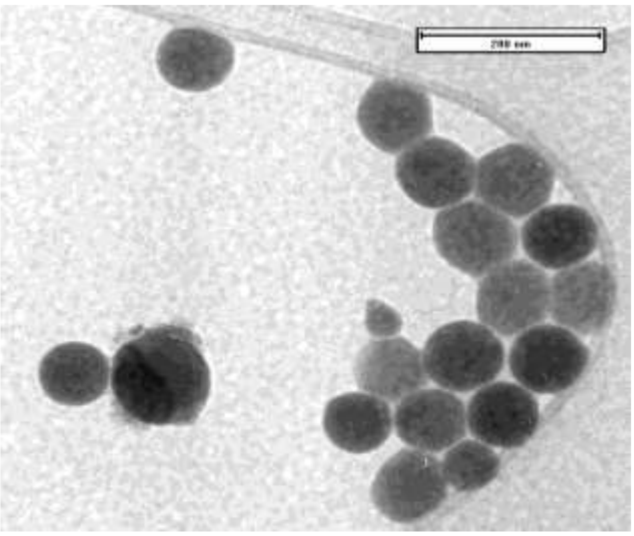


Fig. 1. Results of transmission electron microscopy of the preparation applied (TEM-image of selenium nanoparticles).

Based on the synthesized drug, five samples of the solutions were applied each time applied in the mineral water of the Krasnoarmeysk spring by mixing with the help of a mixer the top-wheel US-2200D at a speed of 2000 rpm for 5 minutes. Further, each group was exposed to external factors: low temperature, ultrasound, sunlight, room temperature.

The stability of the mixtures obtained was evaluated by the size of dispersed particles. After a month of storage, the parameters of the supernatant of each of the solutions were studied.

Using the method of photon correlation spectroscopy, we determined the sizes of dispersed particles. The method is distinguished by high speed and accuracy, does not require additional sample preparation, and makes it possible to determine the hydrodynamic radius of nanoparticles and micelles [20]. The method is one of the modern and widely used for the analysis of liquid turbid systems, colloids, allows you to analyze suspended particles [21].

Samples of the first group were deposited to study the stability of nanoparticles in mineral water as a result of storage at a temperature of 5-10 ° C for a month. During the analysis of the samples, we obtained histograms by which we can estimate the particle sizes. Schedule identified the main indicators for the supernatant, are given in Table I.

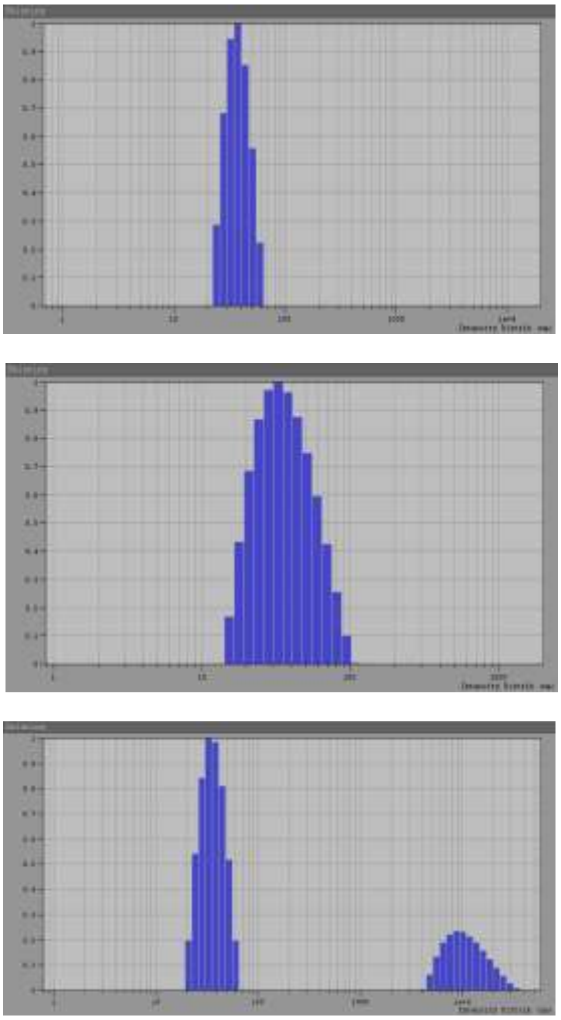
The possibility of obtaining a solution with aggregatively stable selenium nanoparticles with a hydrodynamic radius of 37.5–38 nm is shown - histogram of the normalized distribution of selenium nanoparticles in hydrodynamic radii.

Samples of the second group were subjected to 18 kHz ultrasound (Fig. 2a). Samples of the third group were exposed to sunlight for two weeks (Fig. 2b). Samples of the fourth group were stored at room temperature for two weeks (Fig. 2c).

Based on the indicators of the average particle size applied in composition № 1, it can be concluded that they are closest to the original. This composition was selected for further study as the main one.

TABLE I. The Results of Determining the Normalized Distribution of Selenium Nanoparticles in Hydrodynamic Radii.

Sample number	**Faction number**	**The mole fraction of the fraction of nanoparticles in the system**	**Average hydrodynamic radius of nanoparticles in a fraction**	**Hydrodynamic radius of nanoparticles prevailing in this fraction**	**Standard deviation**
1	1	1,000	37,97	37,58	9,280
2	1	0,011	0,006	0,006	0,001
	2	0,989	38,75	32,66	17,47
3	1	0,728	36,28	32,62	9,871
	2	0,272	1,2*104	8792,0	5466,0
4	1	1,000	44,77	45,20	7,999



a.

b.

c.

Fig. 2. Histogram of the normalized distribution of selenium nanoparticles in hydrodynamic radii.

IV. Conclusion

The possibility of obtaining a solution with aggregatively stable selenium nanoparticles is shown. Based on the indicators of the average particle size deposited in the samples, it can be concluded that nanoscale retains its structure as part of the mineral water of the Red Army source.

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