UDC: 535.621.373.826

PROPERTIES OF GOLD NANOPARTICLES PRODUCED BY LASER ABLATION VOLUME TARGETS IN DIFFERENT ENVIRONMENTS

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In this work the Au nanoparticles are obtained by ablation of golden target in liquid solvents. It is found that depending on the environment of the gold nanoparticles have different diameters. The position of the maximum absorption of the plasmon of Au nanoparticles depends on the environment. It found that stable nanoparticles of Au that were prepared in acetone, isopropyl alcohol and ethylene glycol as the change of optical density values are insignificant. Shortwave maximum in the spectrum of the scattering particles are associated with the scattering of light by small particles, and the long-wave scattering - by large particles.

Keywords: laser ablation, gold nanoparticles, enviroment, absorption and scattering spectrum, optical density, surface morphology of the nanoparticles

Introduction

Laser ablation of solids in liquids is one of the alternative methods for generation of nanoparticles in fluids. Unlike chemical synthetic methods nanoparticles obtained by laser ablation of solid targets in fluids can in principle be free of surfactants and other ions. The properties of the nanoparticles produced during the laser ablation of solids in liquids, depends on many experimental parameters such as laser wavelength, energy density beam at the target, the type of fluid, etc. [1]

Currently, the number of studies on the ablation of solids in liquids is continuously increasing [2, 3]. Thus, there was formation of NP Ag, Au and Cu [4, 5]. Laser radiation is also used to modify the size of the colloidal particles of Ag, and LF made up of an alloy of gold and silver, prepared by chemical means [6-7].

The essence of the physical phenomena determining the laser deposition process can be divided into stages: the interaction of laser radiation with the target, which leads to its evaporation; expansion evaporation products; formation of colloidal solutions of nanoparticles in the environment [8]. Lack of understanding of the essence of each of the stages and their interaction leads to the fact that any deviation from the process parameters considered optimal, can unpredictably affect the final result of spraying. This situation points to the need to continue experiments on the study of physical phenomena occurring at each stage. There are special experiments are necessary in order to clarify for the ablation, expansion of the target material and the formation of nanoparticles.

Experimental part

Au nanoparticles were prepared by ablation of gold target in liquid solvents by second harmonic solid state Nd-laser: Laser YAG (1) (LQ SOLAR 215 λ_{gen} = 532 nm, E_{imp} =90 mJ, τ = 10 ns). Block diagram for receiving of nanoparticles by laser ablation in liquids is shown in Figure 1.

The laser beam was directed by a mirror (1) and focused by a lens (2) in the horizontal target location - plate Au (5) located in the cell with the liquid (4). The beam diameter at the target surface was 0.01 cm^2. The medium was used water, isopropyl alcohol, acetone, ethylene glycol, ethyl acetate and toluene. The concentration of Au nanoparticles was determined from the weight change before and after the target ablation and was $3.5*10^{-4}$ mol/l for 10 minutes of ablation. The average

size of Au nanoparticles was determined by dynamic light scattering particle submicron size analyzer Zetasizer Nano ZS.

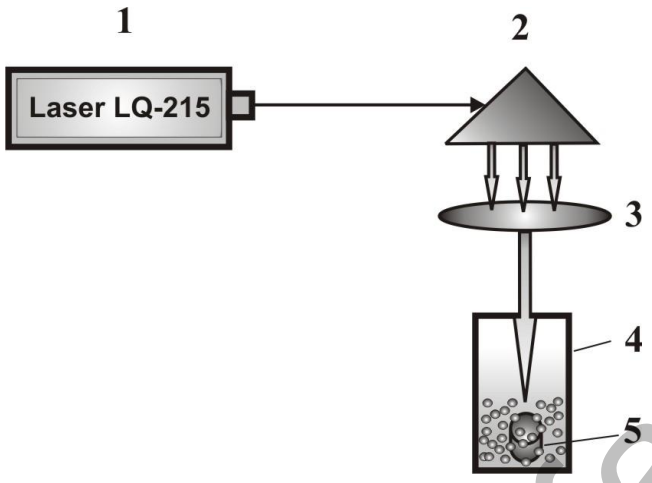


Fig.1. Apparatus for obtaining nanoparticles of gold by laser ablation in liquids

Results and discussion

It has been found that, depending on the environment of the average size of the nanoparticles have different values. The smallest size of Au nanoparticles obtained in ethylene glycol (d = 5 nm) and greatest – for acetone (d = 300 nm) (Figure 2, 3).

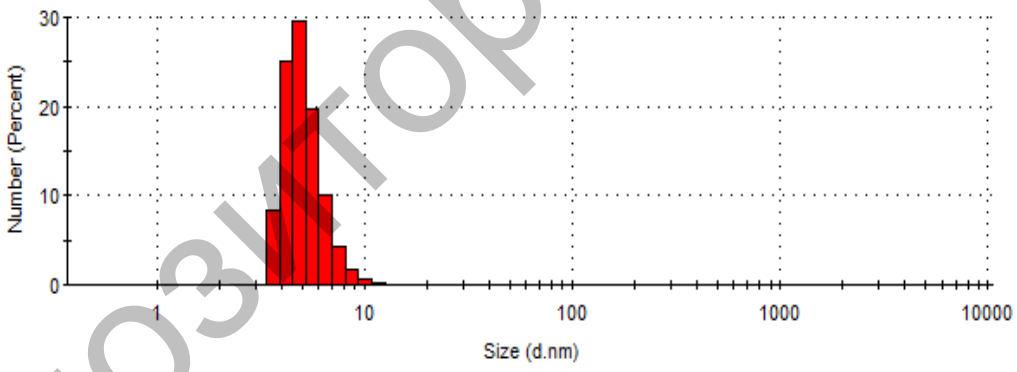


Fig.2.The size distribution of Au Np in ethylene glycol

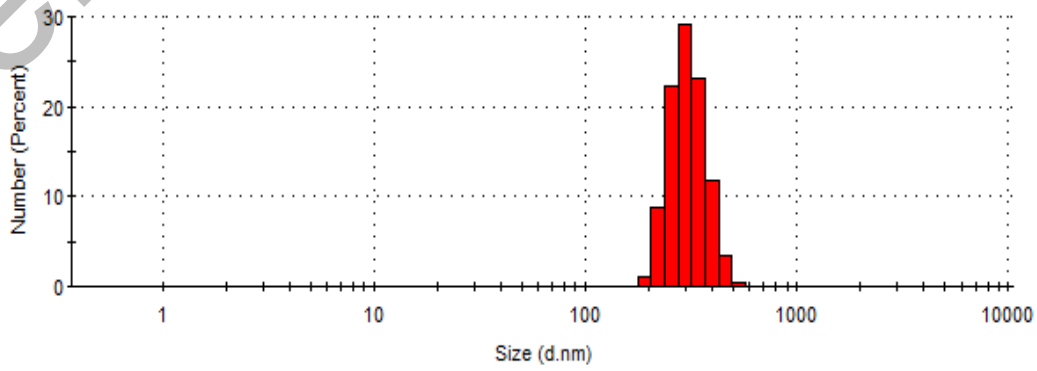


Fig.3. The size distribution of the Au Np in acetone

Surface morphology of the nanoparticles was studied with an electron microscope Tescan Mira 3 MLU. For microscopic pictures suspension of nanoparticles in a liquid solvent applied onto the surface of glass substrate coated with a conductive layer of indium tin oxide (ITO). Then, the substrate was dried in a thermal cabinet for 20 minutes.

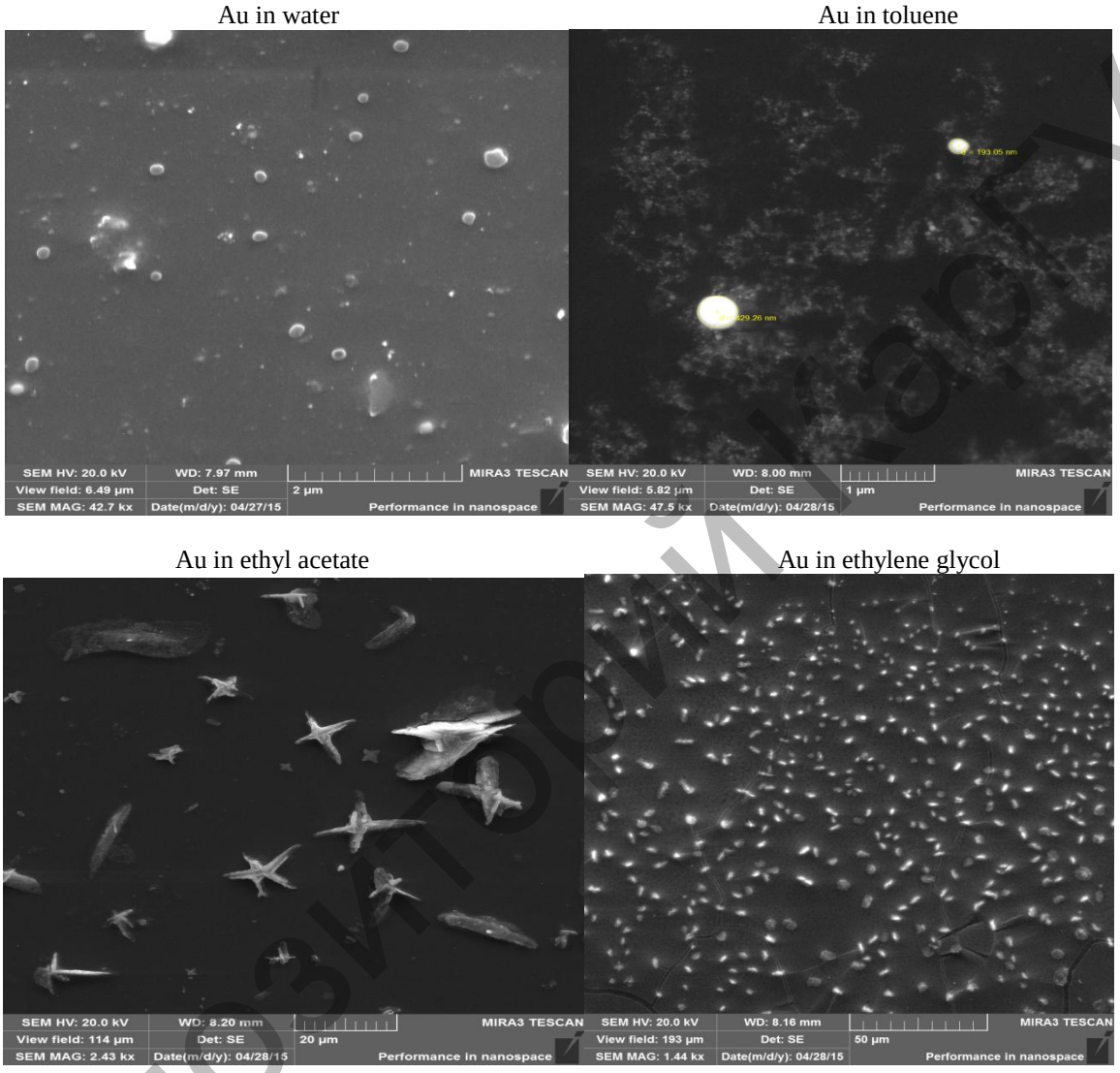
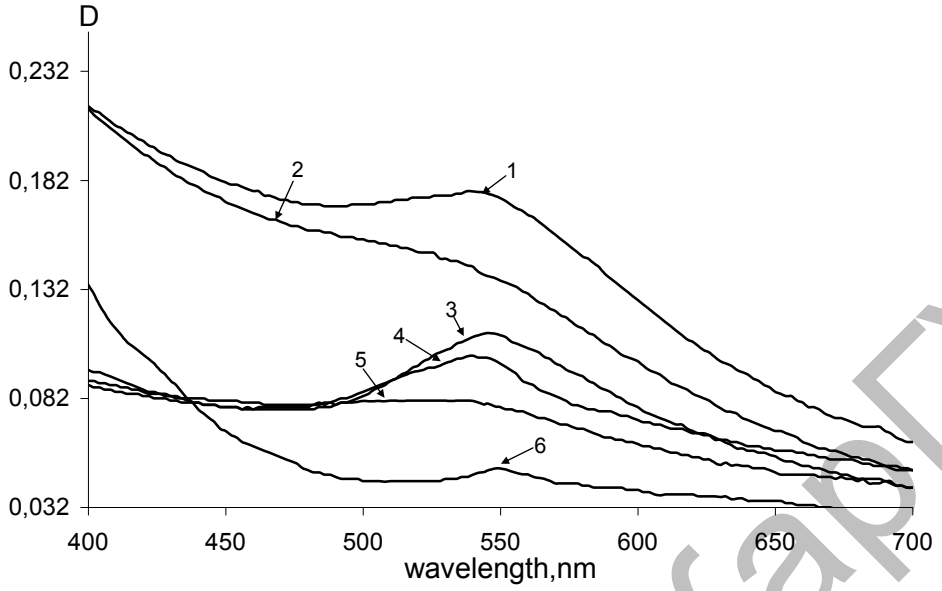


Fig.4. SEM image of Au nanoparticles in various solvents

During evaporation of the solvent from the surface of the substrate nanoparticles forms agglomerated nanostructures which are composed of a plurality of individual clusters of nanoparticles (Figure 4). It was established that in almost all the investigated medium is observed mainly spherical shape of the nanoparticles with the exception of ethyl acetate and ethylene glycol where produced nanoparticles are star-shaped and elongated.

Registration of absorption spectra of Au nanoparticles was carried out with a spectrometer SM Solar 2203 (SOLAR, Belarus). Figure 5 shows the absorption spectra of Au nanoparticles in different environments. In all the studied environments Au nanoparticles have a plasmon absorption peak. In acetone plasmon absorption peak exhibits at λ = 530 nm. The absorption spectra of the nanoparticles in water, isopropyl alcohol and toluene plasmon absorption peaks are observed at wavelengths equal to 538, 544 and 550 nm, respectively. Table 1 shows the characteristics of Au nanoparticles, obtained by laser ablation in different environments.



1- isopropyl alcohol; 2- acetone; 3-acetate; 4- ethylene glycol; 5-water; 6- toluene

Fig.5. The absorption spectra of gold nanoparticles produced by laser ablation

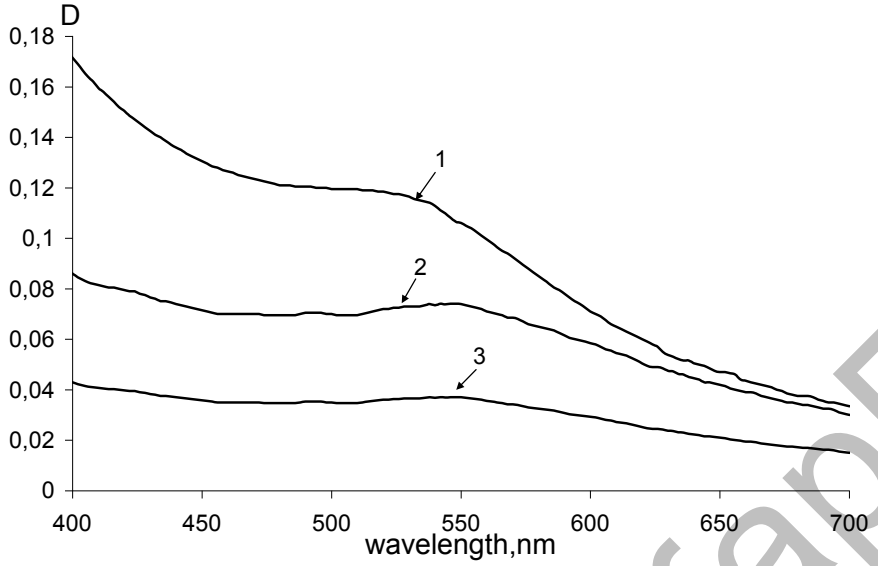
Table 1. The properties of nanoparticles of Au, produced by laser ablation in the various environments

№	Enviroment	λ_{abs}^{max}, nm	Diameter, nm
1	Acetone	530	300
2	Ethylene glycol	544	5
3	Ethyl acetate	548	27
4	Water	538	14
5	Isopropyl alcohol	544	43
6	Toluene	550	270

The dynamics of the absorption spectra of colloidal solutions containing nanoparticles after 24 hours after their receiving were registered to investigate the stability of the resulting nanoparticles. Figure 6 shows the absorption spectra of Au nanoparticles in the studied solvents.

The figure shows that the absorption spectra of the nanoparticles in acetone, isopropyl alcohol and ethylene glycol do not change in shape, and changes are observed only for the optical density. For other solvents absorption spectra have not plasmon peaks. Stable Au nanoparticles obtained in acetone because changes in the optical density are negligible. Also stable Au nanoparticles were obtained in isopropyl alcohol and ethylene glycol.

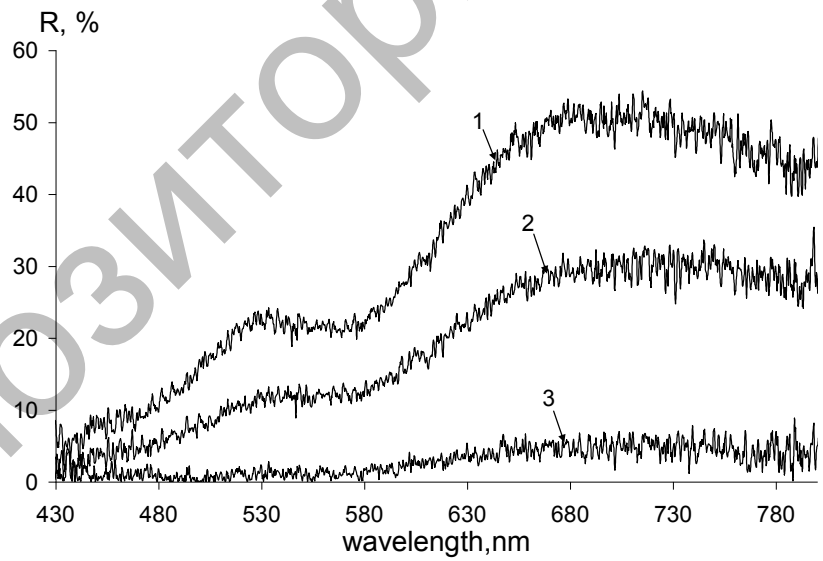
The measurement of the scattering spectra of gold nanoparticles in solvents was carried out using reflectometric scope AvaSphere-50-REFL (Avantes BV) and fiber optic spectrometer AvaSpec-2048. Measurement of light scattering was performed of measuring the proportion of scattered light by nanoparticles in the solution remaining in the field. As a reference sample in the measurement of the scattering spectra of Au Nps cell with solvent was used.



1- acetone; 2- isopropyl alcohol; 3- ethylene glycol

Fig.6. Changes in the absorption spectra of the gold nanoparticles in a solvent after 24 hours

Figure 7 shows the spectrum of the scattering of gold nanoparticles in acetone, toluene and ethylene glycol. The figure shows that the scattering spectra of gold in acetone and toluene have two peaks in the wavelength of 530 nm and 690 nm.



1-acetone; 2 toluene; 3-ethylene

Fig.7. Scattering spectra of Au Np in toluene

At that the long-wave maximum in comparison with the short-significantly is broadened. It is obvious that the short-wave maximum is related to the scattering of light by small particles, and the long-wave scattering by large particles. Light scattering by nanoparticles in ethylene glycol is low and equal in average to 3% since the average size of the nanoparticles are small. In the rest solvents similar result were registered.

Conclusion

Au nanoparticles were obtained by ablation of gold target in liquid solvents. It has been found that, depending on the environment the gold nanoparticles have different diameters. The position of the maximum absorption of the plasmon of Au nanoparticles depends on the environment.

It was found that the absorption spectra in acetone, isopropyl alcohol and ethylene glycol Au nanoparticles do not change shape with the time of storage of solution, there is only a small decrease in the optical density. In other solvents, the absorption spectra of the nanoparticles were not observed. Thus, it can be concluded that stable nanoparticles of Au obtained in acetone, isopropyl alcohol and ethylene glycol as the change of optical density values are insignificant. It was found that short-wavelength maximum in the scattering spectrum is related to the scattering of light by small particles, and the long-wave scattering by large particles.

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Article accepted for publication 23.11.2015