

GENERATION OF SILVER NANOPARTICLES IN A PLASMA-LIQUID SYSTEM WITH A SECONDARY DISCHARGE SUPPORTED BY A ROTATING GLIDING DISCHARGE

V.Ya. Chernyak¹, V.V. Iukhymenko¹, K.V. Iukhymenko¹, O.V. Kolomiets¹, Y.M. Samchenko²,
D.K. Hamazin¹, A.M. Goriachko¹

¹Taras Shevchenko National University of Kyiv, Kyiv, Ukraine;

²F.D. Ovcharenko Institute of Biocolloidal Chemistry NAS Ukraine, Kyiv, Ukraine

E-mail: vyitaliy@ukr.net, chernyak_v@ukr.net

Generation of silver nanoparticles in plasma-liquid system with secondary discharge that supported by rotating gliding discharge was investigated in work. Parameters of liquids after plasma treatment were investigated by absorption spectroscopy method. The Atomic Force Microscope (AFM) was used to determine the particle sizes obtained during the processing.

PACS: 50., 52., 52.50.Dg

INTRODUCTION

Production of nano-materials with different nature, like carbon, non-metallic or metallic nanoparticles in plasma systems is one of the perspective directions of plasma technology [1]. In the world there is a problem with bacteria that are resistant to antimicrobial drugs (they are called super bacteria). Every year they kill up to 700000 people and every year this number increases. Development of new classes of antibiotics is slow and increasingly paying attention to research alternative methods of combating microbial infections. One of the important directions in developing alternative antibiotics is the use of nanoparticles. The noble metal nanoparticles (silver especially) has wide application in medicine: sterilization, healing acceleration and stabilization of bactericidal ointments [2, 3]. One of the effective methods to produce such particles is the processing of these metals salt colloidal solutions using electric discharge. The plasma-liquid system with secondary discharge that supported by rotating gliding discharge can be used for this task. The interest to systems with rotating gliding discharge is caused because such discharge allows obtains non-equilibrium atmospheric pressure plasma with large cross section. This provides a large contact area between the plasma and the treated liquid. The plasma-liquid system with secondary discharge that supported by rotating gliding discharge was used in this work for production of nanoparticles of noble metals. A potential jump created by a secondary discharge above the liquid surface provides more efficient penetration of active particles from plasma into the liquid.

1. EXPERIMENTAL SETUP

The scheme of plasma generator is shown on Fig. 1. The secondary discharge is maintained between the liquid surface and the channel of primary discharge. The plasma-forming gas was supplied in the discharge chamber through two supply channels tangential to the inner cylindrical wall of the reaction chamber. The working liquid was placed below primary discharge in a glass vessel.

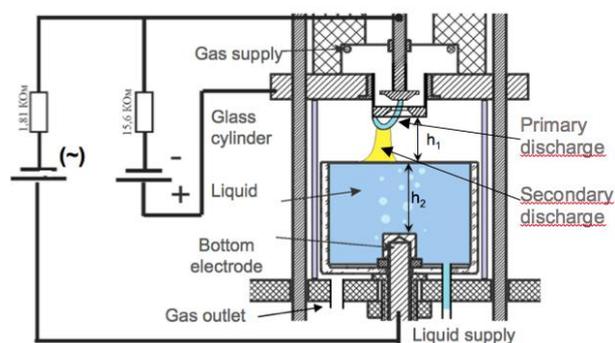


Fig. 1. The scheme of the plasma-liquid system with secondary discharge

The electrical potential is transferred to the liquid through the electrode at the bottom of the vessel. For the generation of discharges, DC and AC power supplies were used. Ballast resistance were used to limit the maximum current and stabilize the discharge mode. Cathode in the system has a conical shape, and anode is made in the form of a flange. The central part of anode is pushed outside the flange to reduce the distance between liquid and plasma of primary discharge. The diameter of the central hole in anode is 6 mm. The distance between electrodes of a primary discharge is 1 mm. The distance between liquid surface and anode of a primary discharge is $h_1 = 1$ cm, and the distance from bottom electrode to the liquid surface is $h_2 = 1.5$ cm. The system is sealed with a glass cylinder in order to be able to work with different gases. Argon (Ar) was used as a working gas.

Solution of AgNO_3 with addition of different concentrations of surface-active substances was used as a working liquid.

Parameters of liquids after plasma treatment were investigated by absorption spectroscopy method. The Atomic Force Microscope (AFM) was used to determine the particle sizes obtained during the processing.

2. RESULTS AND DISCUSSION

The dependence of silver nanoparticles generation from the concentration of PVP (polyvinylpyrrolidone) in solution was investigated in work. AgNO_3 aqueous solutions with addition of surfactant (polyvinylpyrrolidone) in different amounts were treated Table.

The composition of the samples

№	M.M. PVP	C, PVP %
31	50 000	0,038
32	50 000	0,050
33	50 000	0,063
34	50 000	0,076
35	40 000	0,063

The solutions processed in one mode of the system. The current of primary discharge (rotating gliding discharge) was 100 mA and the voltage was 160 V. The secondary discharge was the alternating current. The current of secondary discharge was 100...180 mA and the voltage was 1.9...2.2 kV. The Ar flow was 10 l/min, solution processing time 90 s.

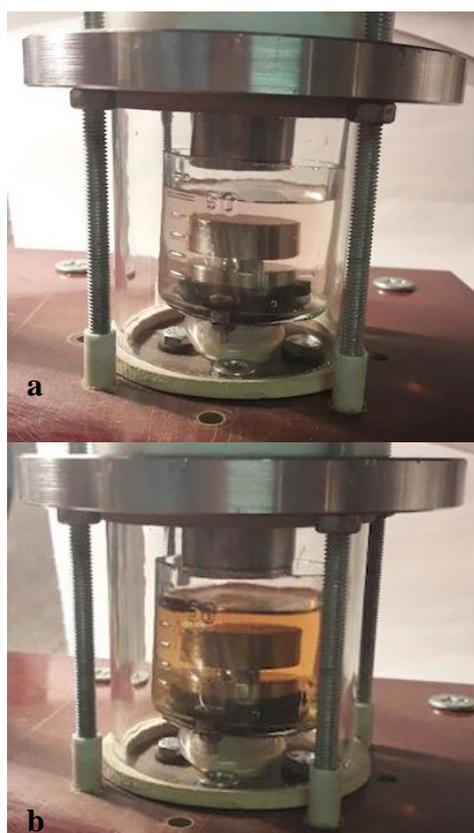


Fig. 2. Photo of a plasma-liquid system and solution: a – before treatment; b – after treatment

During the treatment, the color of solutions was changed. The Fig. 2 shows photos of the plasma-liquid system and solution in it before and after processing.

The absorption spectra of AgNO_3 aqueous solutions before and after plasma treatment are shown on Fig. 3.

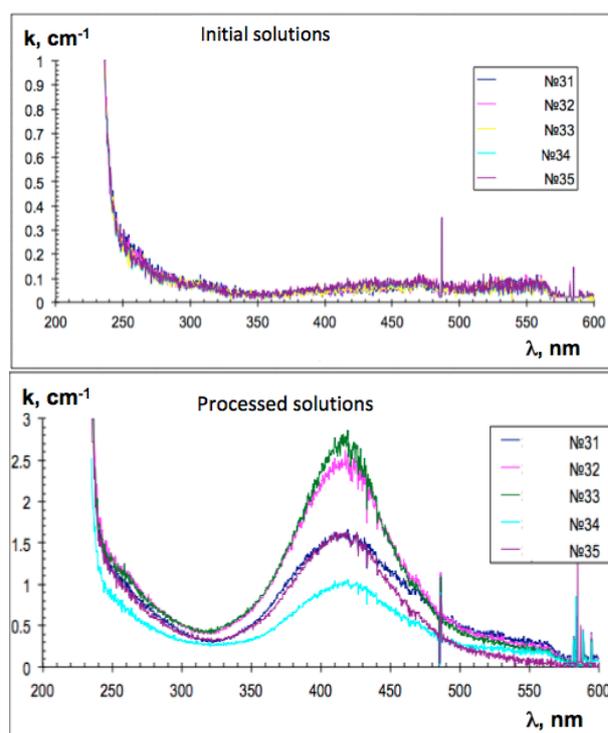


Fig. 3. The absorption spectra of AgNO_3 aqueous solutions. Processing time 90 s. Flow of argon 10 l/min

From absorption spectra we can see that in solutions after plasma treatment an intensive absorption band in the vicinity of 420 nm is observed. This band and darkening of the solution indicates about formation of silver nanoparticles.

To see if solutions are changing in time absorption spectra of processed solution were measured for several days.

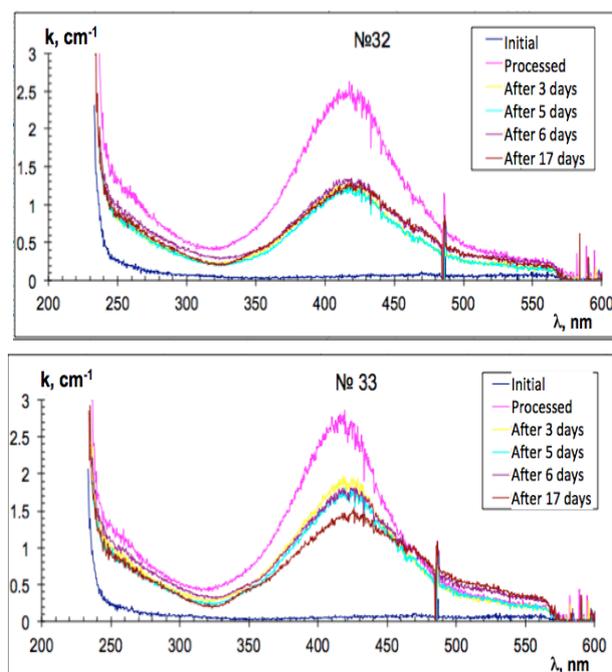


Fig. 4. The absorption spectra of AgNO_3 aqueous solutions. Processing time 90 s. Flow of argon 10 l/min. Stability of treated solutions

The absorption spectra of solutions were changed in time. The maximum in the vicinity of 420 nm for samples 31, 34 and 35 decreased. These solutions returned to the initial state that was before processing. The solutions become transparent. Samples 32 and 33 remained yellow (Fig. 4). These two samples proved to be quite stable in time. The maximum in the vicinity of 420 nm in these samples decreased by 1.5...2 times in three days and settled down. The absorption spectra for samples 32 and 33 correlate with the preliminary results obtained for the PVP concentration of 0.063 %.

The distributions of the particle size obtained on the AFM for solutions that have been stabilized are shown on Figs. 5, 6. To determine the size of the particles on the AFM solutions were diluted in 10 times.

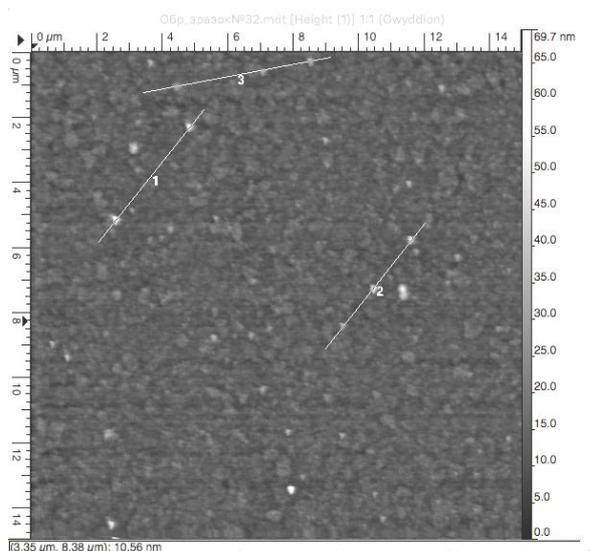


Fig. 5. The image obtained on the AFM and particle size distribution

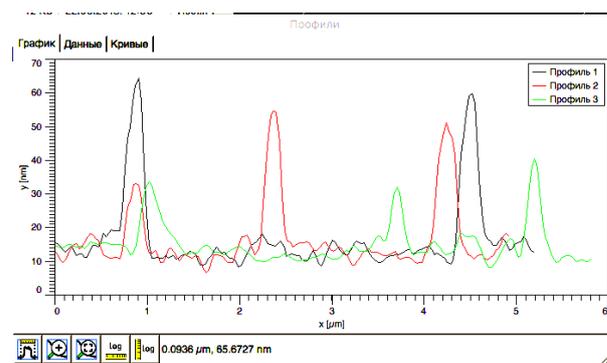


Fig. 6. Particle size distribution

CONCLUSIONS

1. The sizes of nanoparticles measured a few days after processing were tens nanometers.
2. The process of dropping silver from nitrate in aqueous solution is quite intense, but in some cases it leads to the formation of macrophages, followed by their deposition.

REFERENCES

1. A. Fridman, G. Friedman. *A John Wiley and Sons. Ltd. Publication*, 2013, 545 p.
2. A.R. Shahverdy, A. Fakhimi, S. Minaian. Synthesis and effect of silver nanoprecipitates on the antibacterial activity of different antibiotics against *Staphylococcus* and *Escherichia coli* // *Nanomedicine-Nanotechnology Biology and Medicine*. 2007, v. 3, № 2, p. 168-171.
3. A.B. Landsdown. *Silver in healthcare: Its antimicrobial efficacy and safety in use*. Cambridge: "Royal Society of Chemistry", 2010, 217 p.

Article received 18.10.2018

ГЕНЕРАЦІЯ НАНОЧАСТИЦ СЕРЕБРА В ПЛАЗМОЖИДКОСТНОЇ СИСТЕМІ С ВТОРИЧНИМ РАЗРЯДОМ, ПОДДЕРЖИВАЕМЫМ ВРАЩАЮЩИМСЯ СКОЛЬЗЯЩИМ РАЗРЯДОМ

В.Я. Черняк, В.В. Юхименко, К.В. Юхименко, О.В. Коломиец, Ю.М. Самченко, Д.К. Гамазин, А.Н. Горячко

Исследовалась генерация наночастиц серебра в плазможидкостной системе с вторичным разрядом, поддерживаемым вращающимся скользящим разрядом. Параметры жидкостей после плазменной обработки исследовались методом абсорбционной спектроскопии. Атомно-силовой микроскоп (АСМ) использовался для определения размеров частиц, полученных во время обработки.

ГЕНЕРАЦІЯ НАНОЧАСТИНОК СРІБЛА В ПЛАЗМОВО-РІДИННІЙ СИСТЕМІ З ВТОРИННИМ РОЗРЯДОМ, ЩО ПІДТРИМУЄТЬСЯ ОБЕРТОВИМ КОВЗНИМ РОЗРЯДОМ

В.Я. Черняк, В.В. Юхименко, К.В. Юхименко, О.В. Коломїєць, Ю.М. Самченко, Д.К. Гамазін, А.М. Горячко

Досліджувалась генерация наночастинок срібла в плазмворідинній системі з вторинним розрядом, що підтримується обертовим ковзним розрядом. Параметри рідини після плазмової обробки досліджувались методом абсорбційної спектроскопії. Атомно-силовий микроскоп (АСМ) використовувався для визначення розмірів частинок, які були отримані під час обробки.