

# Study of the optical and electrical properties of colloidal silver solutions

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The silver colloidal solutions were prepared by chemical and electrochemical methods. Depending on the chosen method, the AgNp concentration was varied between 7.5 and 100 ppm. The optical absorption spectra were registered for all the samples in the range 190-1100 nm. Particle's shape and size were determined by transmission electron microscopy (TEM). Stabilizing agents were used to obtain a good dispersion of particles.

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*Keywords:* Silver colloidal solutions, Zeta potential, TEM, UV-VIS spectra

## 1. Introduction

One the last decade many researchers groups have been focused on the study of physical properties of colloidal silver solutions. This interest is due to the fact that noble metals nanoparticles have many attractive applications in different areas like medicine, microelectronics and energy conversion [1-4].

Colloidal silver solutions have become interesting to study because of their antimicrobial behavior, which offer important applications in biology, pharmacology and other fields. More over, the silver nanoparticles can be used as colloidal sols or even doping agents for materials with polymer matrix [1].

Despite all these applications, a proper preparation can be achieved if the processes related with time stability are well understood [5]. A poor stability affects the silver nanoparticles applicability [5], so many methods have been developed to synthesize these kind of solutions. The synthesis in organic media is convenient because there is no need of supplementary reducing agents [6,7].

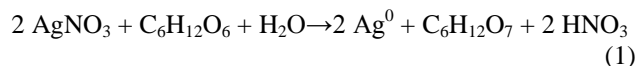
The paper presents the study of physical properties of colloidal silver solutions obtained by chemical and electrochemical methods and varying the AgNp concentration.

## 2. Experimental procedures

Silver nitrate (AgNO<sub>3</sub>, 99.9% pure, Merck) was used as a precursor and glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>, 99.95% pure, Merck) as a reducing agent.

The reducing agent and the precursor, AgNO<sub>3</sub>, were used to prepare two silver colloidal solutions by electrical and electrochemical procedures. The chemical methods involved silver ion reduction from AgNO<sub>3</sub> solutions in polar and nonpolar solvents.

*Preparation of the silver colloids:* Silver colloids were prepared using sol-gel dissolved in distilled water in different containers under the same conditions. Next, the two solutions were mixed and stirred until a colorless or transparent aqueous solution, which contained nAg particles, was formed. The nano-sized silver colloidal solutions were prepared at 0.5 μg/ml, 1 μg/ml, 2 μg/ml, 3 μg/ml, 4 μg/ml and 5 μg/ml Ag concentrations according to the following reaction [1]:



The colloidal solutions obtained by electrochemical methods were stable and pure. Using stabilizing agents facilitates a good dispersion of particles and prevent their agglomeration. The solutions have different concentrations of AgNp in the range 5-35 ppm for those obtained by electrochemical synthesis and between 7.5-100 ppm AgNp for those obtained by chemical procedures.

For the obtained solutions were performed optical characterizations using an UV-VIS Perkin Elmer spectrophotometer, in the range 190-1100 nm. The instrument was a UV-Vis spectrophotometer.

It measures the intensity of light passing through a sample ( $I$ ), and compares it to the intensity of light before it passes through the sample ( $I_0$ ). The ratio  $I / I_0$  is called the transmittance, and is usually expressed as a percentage (%T). The absorbance,  $A$ , is based on the transmittance:  $A = -\log (\%T)$ .

The chemical composition was analyzed by atomic absorption spectroscopy (AAS). The particle's size were determined and their distribution was analyzed. For all the samples was determined the zeta potential.

### 3. Results and discussions

The absorption and transmittance spectra were recorded for all the samples, at room temperature, and the results were presented in Figs. 1 and 2.

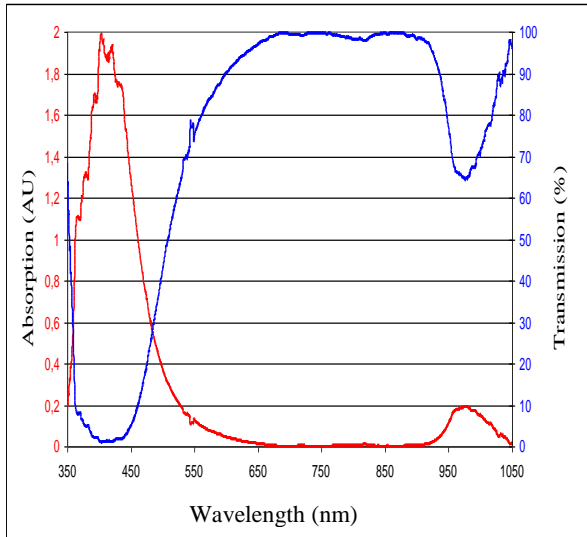


Fig. 1. UV-VIS transmittance and absorption spectra of CSS obtained by electrochemical synthesis.

The samples obtained electrochemical showed an optical transmittance higher than 90% for the visible range and two absorption peaks at 375 and 425 nm. In the range 350 – 450 nm the absorption is around 2 a.u.

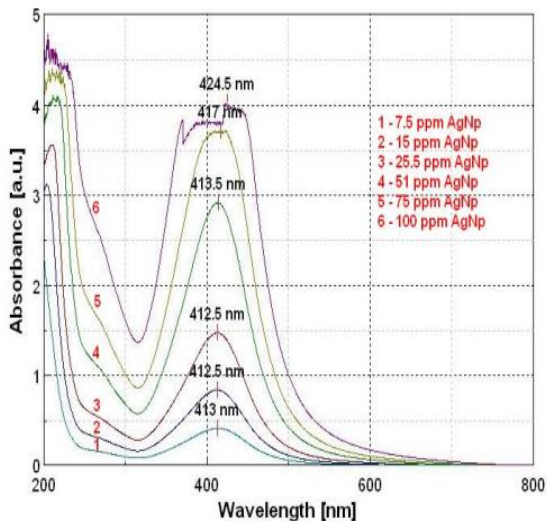


Fig. 2. UV-VIS absorbance spectra of CSS obtained by chemical synthesis.

The samples obtained by chemical methods have a peak at 400 nm and we can notice that the AgNP concentration strongly influence the absorbance; the highest value was registered for the sample with 100 ppm AgNP. The absorbance increases from less than 1 a.u. for

the sample with 7.5 ppm AgNP to almost 4 a.u. for that with 100 ppm AgNP concentration. Spectrum shape and peak position do not change regardless the AgNP concentration.

The colloid's size was determined and the average was 100 nm. The results were presented in Fig. 3.

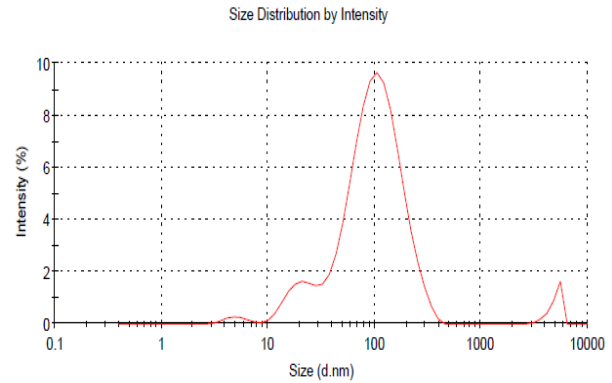


Fig. 3. Colloid silver distribution.

Average result created from record number (s): 1 2 3, dispersant name: water, dispersant RI:1.330, material RI:1,35, viscosity(mPa.s): 0,8872, material absorbtion: 0,10, System

Temperature(<sup>0</sup>C): 25,0, count rate (kcps): 280,3. Cell Description:Clear disposable zeta cell.

Duration Used (s): 60, measurement Position (mm): 4,65 attenuator: 5.

According to Fig. 3 we can observe three peaks, first at 87,2% intensity with a width of 62,4 nm, second at 8,6% intensity and 5,18 nm width and the last one at 3,0% intensity and 643 nm width.

Zeta potential distribution is presented in Fig. 4.

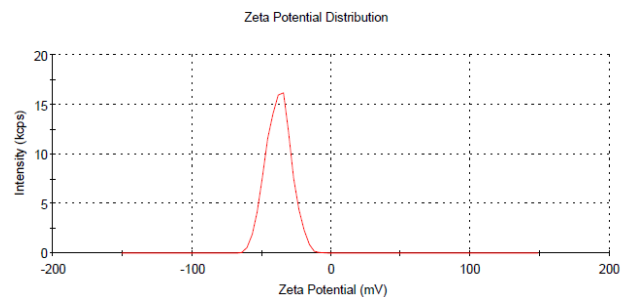


Fig. 4. Zeta potential distribution.

Generated Notes:Average result created from record number(s): 5 6 7, Dispersant name: water, dispersant RI:1.330, viscosity (mPa.s): 0.8872, record number: 8, dispersant dielectric, Constant: 78,5. System Temperature (<sup>0</sup>C): 25,0, zeta runs: 23, count rate (kcps): 2171,9,

measurement position (mm): 2.00, cell description: clear disposable zeta cell, attenuator: 8.

Zeta potential distribution is a monomodal one, with value  $-37,6$  mV that suggest the particles are covered by stabilizer and thus, the solution is stable. Analyzing the results obtained from zeta potential distribution we can conclude that the prepared samples have a good stability even if they are chemically or electrochemically obtained.

#### 4. Conclusions

Colloidal silver solutions were successfully prepared by chemical and electrochemical methods. The optical characterizations revealed that the samples obtained electrochemically have a transmittance higher than 90% for visible range and a good absorption in the 350 – 450 nm range. Zeta potential distribution is a monomodal one, with value  $-37,6$  mV that suggest the particles are covered by stabilizer and thus, the solution is stable. The colloid's size was determined and the average was 100 nm.

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