SYNTHESIS OF MICRO-SIZED SILVER PARTICLES SUITABLE FOR THICK FILM CONTACTS ON SOLAR CELLS

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Abstract

The main goal of the study was to determine parameters for the production of the micro-sized silver powder applicable to the pastes that are in use in solar cell production and maintenance. In all experiments, **silver nitrate solution and ascorbic acid** were used, as a **silver source and reducing agent**, respectively. **PVP and gelatin** were used **as dispersants**. The dispersant in this system acts as a protective agent in a way that prevents agglomeration and aggregation processes. The influence of used agents was different, and one of the aims in the research was to determine the pros and cons of them. The optimal parameters of the synthesis were the solution temperature of 45 °C, pH=7, and concentrations of silver and ascorbic acid of 45 g/l and 30 g/l, respectively. Although, PVP has proved to be a suitable protecting agent for the goals of the study, **the best results were obtained with the use of gelatin as a dispersant in the concentration ratio against the silver ions of 2.5 wt. %.**

Key words: silver; past; electrical contacts; solar cells; thick films.

INTRODUCTION

Silver nanoparticles and nanostructures have been studied due to their exceptional properties that are conditional and determined by their unique interfacial effects.

This provides very special applications in many fields of applied science such as:

- **biotechnology**
  (biosensors, pest & microbial control, biosynthesis)
- **pharmaceutical industry,**
- **special catalysis processes,**
- **photonics, photovoltaic devices,**
- **biofuels,**
- **lithium batteries,**
- **and many others**

INTRODUCTION 2

The most important synthesis methods, for silver nanoparticles obtaining are:

- chemical reduction,
- use of gamma-rays and laser-assisted processes,
- electrochemical procedures,
- photochemical reduction, template method, and various biosynthesis.

Chemical reduction with the support of the polymer systems is still the simplest but very effective method, with low costs and excellent control of the particle size. The silver powder with the particle size of 500-1500 nm has been extensively used for conductive inks and pastes.

The aim of the paper is to establish maximal concentration of the reagents for the wet chemical reduction synthesis of the microsized silver in goal to achieve the most enonomic process for use in small and medium industry conditions.

RESULTS AND DISCUSSION

1) The classical chemical reduction of Ag^+ ions with vitamine C (ascorbic acid) in the presence of PVP polymer

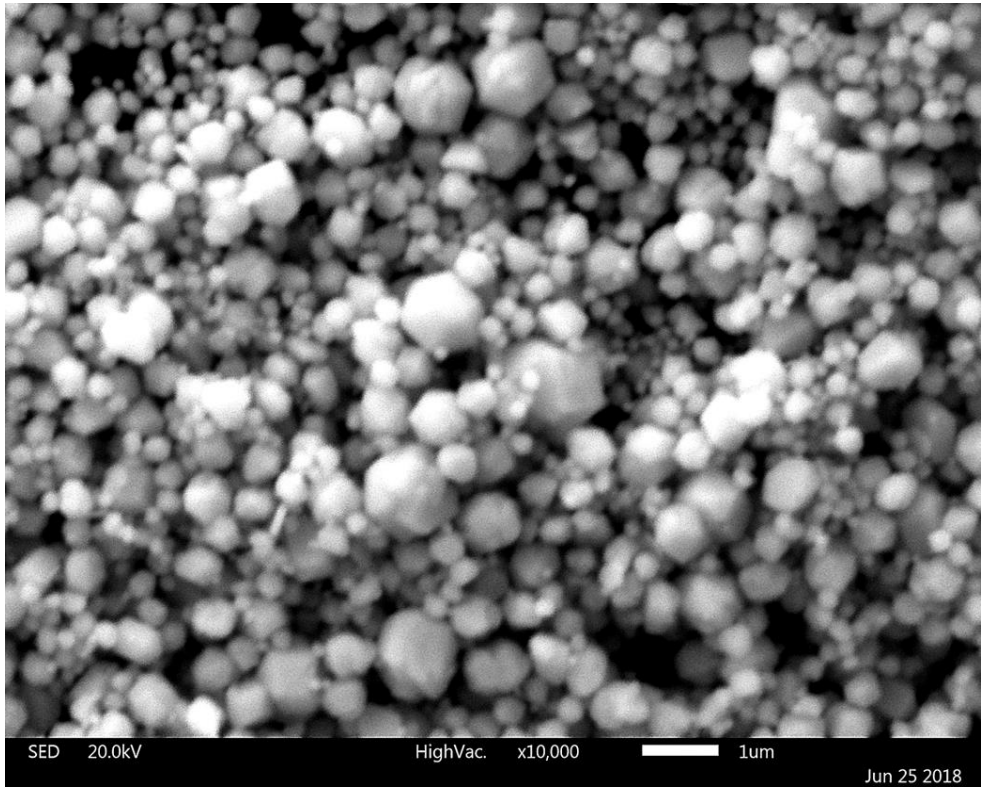

Figure 1. Silver powder after reduction of Ag^+(45 g/L) with ascorbic acid (30 g/L); 10 g/L PVP

The benefit of the method is that it is simple, inexpensive, and good enough for fine powder with particles with a size of 1-2 μm. As can be seen in figure 1, silver powder has a **wide distribution of particle size**, **which is the main disadvantage of the procedure.** Particle size is mainly from 300 nm up to 3 μm, with the majority in the interval from 500 to 2000 nm.

RESULTS AND DISCUSSION 2

1.1) Chemical reduction of Ag^+ with vitamine C + PVP with lowering the concentrations of silver ions and vitamine C

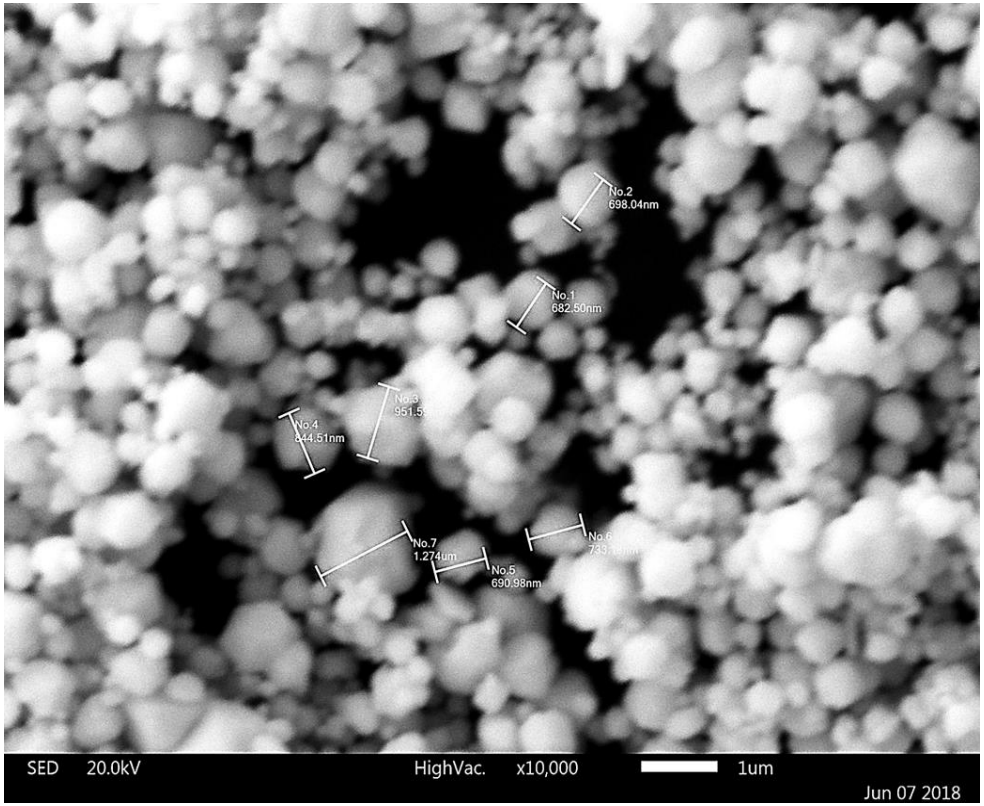

Figure 2. Silver powder after reduction of Ag^+ (30 g/L) with ascorbic acid (20 g/L); 10 g/L PVP

The lowering of the reagens concentrations leads to the better results of particle size and size distribution.

However, it decrease the yield of the reaction which is now between 95 and 98%, and was 100% in the previous test.

Lower concentrations = higher costs of the production.

RESULTS AND DISCUSSION 3

2) Chemical reduction of Ag^+ with vitamine C in the presence of gelatin as dispersant

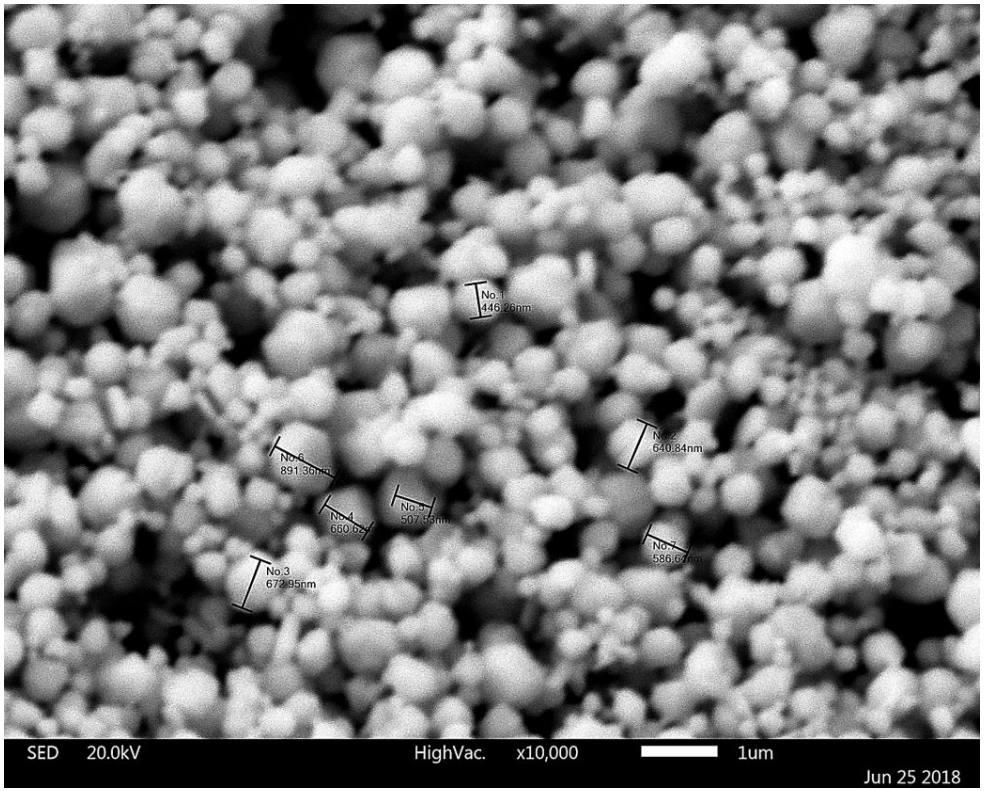

Figure 3. Silver powder after reduction of Ag^+ (30 g/L) with ascorbic acid (20 g/L); 0.75 g/L gelatin

The improvement over the use of PVP is in the more spherical particles, smaller particles, and lower costs (not just that gelatin is less expensive than PVP, but the lower concentration is needed).

RESULTS AND DISCUSSION 4

2) Chemical reduction of Ag^+ with vitamine C in the presence of gelatin as dispersant – granulometric analysis

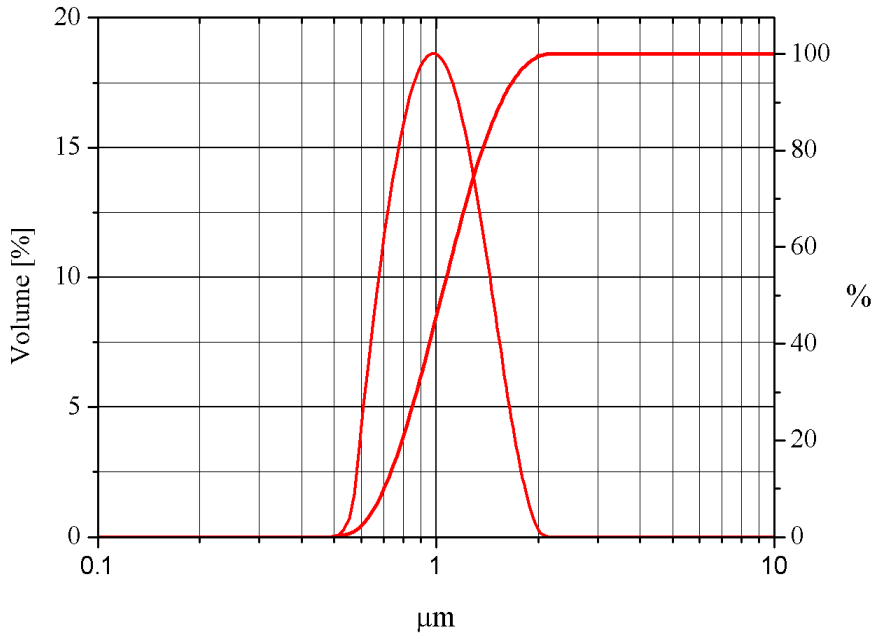

Figure 4. The granulometric composition of the powder obtained by use of gelatin, 2,5% of silver

Figure 4 illustrates quite a narrow size distribution, LD gives values from 0.5 to 2 μm, and the average value of about 1 μm. The cumulative curve also shows that about 80% of the particles are smaller than 1.5 μm.

CONCLUSIONS and Acknowledgments

CONCLUSIONS

1) The study has shown that even high concentrations of reagents (silver ions and ascorbic acid) and low concentration of PVP can produce a silver powder with an average size between 1 and 2 μm. The disadvantage of that reaction parameter is the very wide size distribution of the particles.
2) Optimization of parameters with the same reagents gives better results, with the average size of nearly 1 μm and narrower size distribution of the particles.
3) **Further improvement was achieved by the use of gelatin instead of PVP polymer.** Smaller and more spherical particles with a further decrease of the size distribution are obtained. **This silver powder can be used for the thick film technology that would be applied in the solar energy industry.**

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Thank you for your attention!!