RESEARCH ARTICLE

Green Synthesis of Silver Nanoparticles Using *Avena sativa L.* Extract

Nooshin Amini[1,2]*; Gholamreza Amin[3]; Zahra Jafari Azar[4]

[1]Department of Nanochemistry, Faculty of Pharmaceutical Chemistry, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran, Iran

[2]Drug Delivery System Research Center (DDSRC), Pharmaceutical Sciences Branch, Islamic Azad University, Tehran, Iran

[3]Department of Pharmacognosy, Faculty of Pharmacy, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran, Iran

[4]Department of Pharmaceutics, Faculty of Pharmacy, Pharmaceutical Sciences Branch, Islamic Azad University, Tehran, Iran

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ABSTRACT

Objective(s): Nowadays, nanoparticles bio production, considering their performance in medicine and biological science, is increasing. Green synthesis of metal nanoparticles using organisms has emerged as a nontoxic and ecofriendly method for synthesis of metal nanoparticles The objectives of this study were the production of silver nanoparticles using Avena sativa L. extract and optimization of the biosynthesis process. The effects of quantity of substrate (silver nitrate ($AgNo_3$)) and temperature on the formation of silver nanoparticles are studied.

Methods: In this work, silver nanoparticles were synthesized from an extract of Avena sativa L. at different temperatures (30, 60, 90°C) and $AgNo_3$ concentrations (1mM, 2mM, 4mM). The morphology and size of the nanoparticles were determined using Scanning Electron Microscope (SEM) and Dynamic Light Scattering (DLS).

Results: SEM images showed that by increasing temperature nanoparticles size were decreased and by increasing concentrations of $AgNo_3$ the number of nanoparticles was increased.

Conclusions: The results indicated that by increasing the reaction temperature, the size of the nanoparticles would decrease. Also by increasing the concentrations of $AgNo_3$, the amount of produced nanoparticles would be increased, but won't have a significant effect on its size. The preparation of nano- structured silver particles using Avena sativa L. extract provides an environmentally friendly option as compared to currently available chemical/ physical methods.

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INTRODUCTION

Nowadays, nanoparticles bio production, considering their performance in medicine and biological science, is increasing. The not harmful biological procedures for non-toxic biological materials nanoparticles could be substituted with the conventional chemical procedure used for nanoparticles production [2,3].

Using green plants on biological nanoparticles is an amazing one, and it is some how not well known [4]. It should be mentioned that Nanoparticles produced by plants are more stable, and the rate of synthesis is faster than that in the case of other organisms [18].

Silver nanoparticles have drawn the attention of researchers because of their extensive applications in areas such as Targeted drug delivery [5],

* Corresponding Author Email: *gh_amin@yahoo.com*

antimicrobial [6], anticancer [7], anti tuberculosis [8,9], catalysts [11,12], biosensors [13], agriculture [15], ins catalysts and pests hting [16], cosmetics [17]

Chemical synthesis of silver nanoparticles requires three components: a precursor for silver nanoparticles usually silver nitrate (AgNo3), reducing agents such as sodium borohydrate (NaBH4) and capping agent like Polyvinylpyrrolidone (C6H9NO)n. In chemical synthesis, there is single reducing and capping agent which allow synthesis of nanoparticles with defined shape and size which is the major advantage of this method but the use of hazardous chemicals, harsh reaction parameters such as high temperature, pressure, and toxic by-product creates environmental concern [19]. In the biosynthesis of silver nanoparticles, the reducing and capping agents are replaced by existence molecules in living organisms which these molecules can be present in different biological systems such as bacteria, fungi , yeasts or plants [17].

The biological reduction in conversion of Ag+ to Ag° based on the ability of functional groups such as hydroxyl, carbonyl, and amine to react with silver ions leading to their reduction and subsequently capping around nanoparticles imparting stability to synthesized silver nanoparticles. Proteins, flavonoids, terpenoids, sugars and other plant metabolites have hydroxyl, carbonyl, and amine functional groups. In general, the functional groups present in plant biomolecules reacts with metal ions and thereby reduce metal ions to nanoform with different shapes and sizes [19].

The objective of this study was Silver nanoparticles production and improving its biosynthesis process. In this study substrate (AgNo3) concentration and temperature effects in Silver nanoparticles, the formation was investigated.

MATERIALS AND METHODS

Materials

Silver nitrate and ethanol (96.6%) was purchased from Merck Co. for this study. Avena Sativa L. was provided from Yasdaru Pharmaceutical Co. located in Tehran province, IRAN. All glassware`s are washed with acetone and distilled water and dried in an oven.

Plant gathering and drying

Avena Sativa L. was provided on Feb 2016 from Yas daru Pharmaceutical Co. located in Tehran province, Iran.

The plant was identified by the Pharmacognosy Department of the Faculty of Pharmacy at Tehran University of Medical Sciences. The samples were cleaned with tap and distilled water and dried and ground to powder and stored for further study.

Avena Sativa L. (Poaceae) is an annual grass with erect culms 40–180 cm long. The fruit is hairy all over and has a linear hilum. It seems that at the beginning it grew and spread over Europe and west region of Asia, then been taken to other areas. Nowadays it is supposed that this plant is a species called A. Fatua L. [1].

Plant exeraction

A) Aqueous extract

The powdered samples (150g) were added to boiling distilled water stirred well and heated for 4 hours at 80°C. The extract was filtered and stored in a refrigerator at 4°C. The extract was used as reducing as well as the capping agent.

B) hydro-alcoholic extract

The powdered samples (100g) were macerated with ethanol 60% and left at rest (6 days, room temperature). The material was filtered, and the crude extract obtained. The obtained extract was kept in a dark color container for further study. The extract was used as reducing as well as capping agent.

Silver nanoparticles synthesis

The source of silver was silver nitrate (AgNo3) in deionized water. The typical reaction mixture contained 10 ml of extract in 90 ml of silver nitrate solution (1mM). The reaction mixture was placed on stirring heaters for 24 h. The effect of silver was determined by varying the AgNo3 concentration (1,2,4mM) while the temperature of the reaction was 90°C. Study the effect of temperature on nanoparticle synthesis, the reaction mixtures containing 10 ml extract 90 ml AgNo3 placed on stirring heaters at 30°, 60°, 90°C for 24h. It should be mentioned that all experiments were investigated in both aqueous and hydro-alcoholic extract.

As shown in (Fig. 1) after 24 h the solutions color turned to yellowish brown and then to dark brown which was in agreement with the previous studies and considered as the formation of silver nanoparticles [17-19]. Finally, characterization

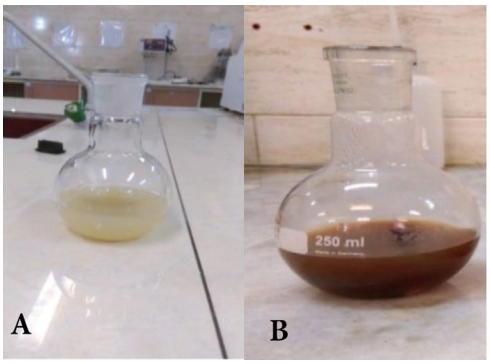

Fig. 1.The crude extract of Avena sativa L. mixed without $AgNo_3$ (A) and with $AgNo_3$ (B) after 24 h. It is observed that the color of the solution turned from yellow to dark brown after 24 h of the reaction, indicating the formation of silver nanoparticles.

methods such as UV-Vis spectrophotometer, DLS, and SEM were used to investigate the process of formation of silver nanoparticles and study the size and shape of them.

Sample preparation for SEM analysis

The synthesized silver nanoparticles solution was centrifuged at about 12000 rpm for 15 min. the obtained precipitation was kept into containers and dried in a 70°C oven for 24h. The remaining material was scraped out from the container and the gained powder was put into a vial for SEM analysis.

RESULTS AND DISCUSSION

UV-VIS spectral studies

The formation of silver nanoparticles was monitored with color change and UV-Vis spectroscopy. After 24 h the color of the solution turned to yellowish brown and then to dark brown which indicates the formation of silver nanoparticles due to the reduction of silver metal ions Ag+ into silver nanoparticles Ag° via the active molecules present in Avena Sativa L. extract.

To confirm the synthesis of silver nanoparticles, the following experiment has occurred. As shown in Fig 2. Part A of the picture shows Erlenmeyer bulb that contained extrat which placed on stirring heater at 90°C for 24h. Part B shows Erlenmeyer flask which contained 90 ml silver nitrate and 10 ml extract placed at room temperature for 24h and Part C shows Erlenmeyer bulb contained 90 ml silver nitrate 10 ml extract placed on stirring heater at 90°C for 24h. The appearance of a brownish color confirmed the formation of silver nanoparticles [17-19].

The UV-Vis spectrum of the reaction mixture did not show any clear absorption peaks in the UV-Visible range. This may due to the agglomeration of particles observed in SEM (Fig 5,6) or too much diluted of the reaction mixture. This case was also seen in Amany A. El-Kheshen et al., 2012 [20] studies they believe that this happened because of agglomeration and decreasing in silver concentration.

UV-Vis spectrum was recorded on Tehran University Pharmaceutical faculty spectrophotometer (Cecil 7500) from 200 to 700 nm. The double distilled water containing the extract was used as a blank. It should be mentioning that the results reached by aqueous extracts and hydro-alcoholic were similar as shown in (Fig. 3).

DLS analysis

DLS technique was used in this study to realize the size distribution profile of synthesized silver

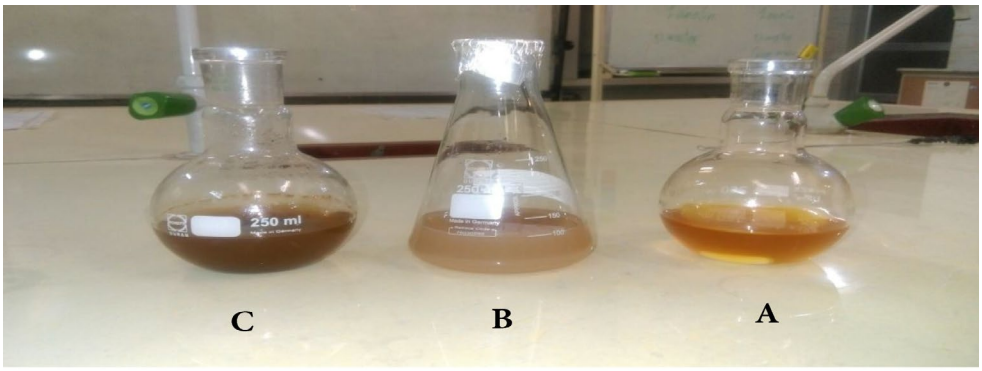

Fig. 2. (A) The crude extract of Avena sativa L. at 90°C for 24 h (B) with $AgNo_3$ at room temperature for 24h (C) and with $AgNo_3$ at 90°C for 24h. The appearance of a brownish color confirmed the formation of silver nanoparticles.

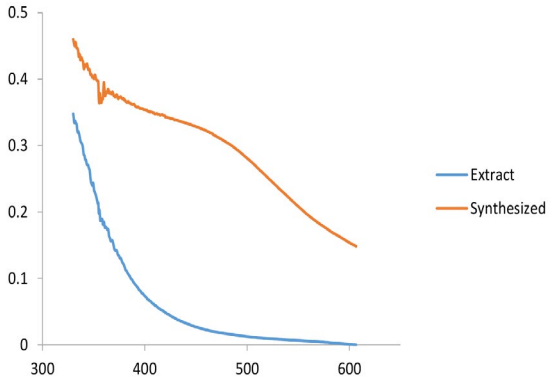

Fig 3.The UV-Vis spectrum

nanoparticles.

For this study reaction mixtures contained the following ingredients: (aqueous, hydro-alcoholic) extract, AgNo3 (1.4 mM) at 90°C for 24h. DLS measurements were carried out using MALVERN ZEN 3600 instrument. DLS results showed (Fig. 4) that by increasing the concentration of the Silver nitrate (both in aqueous and hydro-alcoholic extracts), the number and average size of nanoparticles would be increased which was in agreement with the Iravani. S, et al.[18] work. On that study, they produced silver nanoparticles using Pinus eldarica bark extract and investigate the effects of quantity of extract, substrate concentration, temperature, and pH on the formation of silver nanoparticles.

SEM analysis

The morphology and size of biosynthesized silver nanoparticles were evaluated by SEM (KYKY model EM32000). SEM images of the synthesized silver nanoparticles are shown in Fig.5, 6. The silver nanoparticles are spherical. The diameter of the nanoparticles is found to be ranging from 60 nm to 100 nm. SEM image also shows that the produced nanoparticles are more or less uniform in size and shape. The agglomeration of the particles is clear.

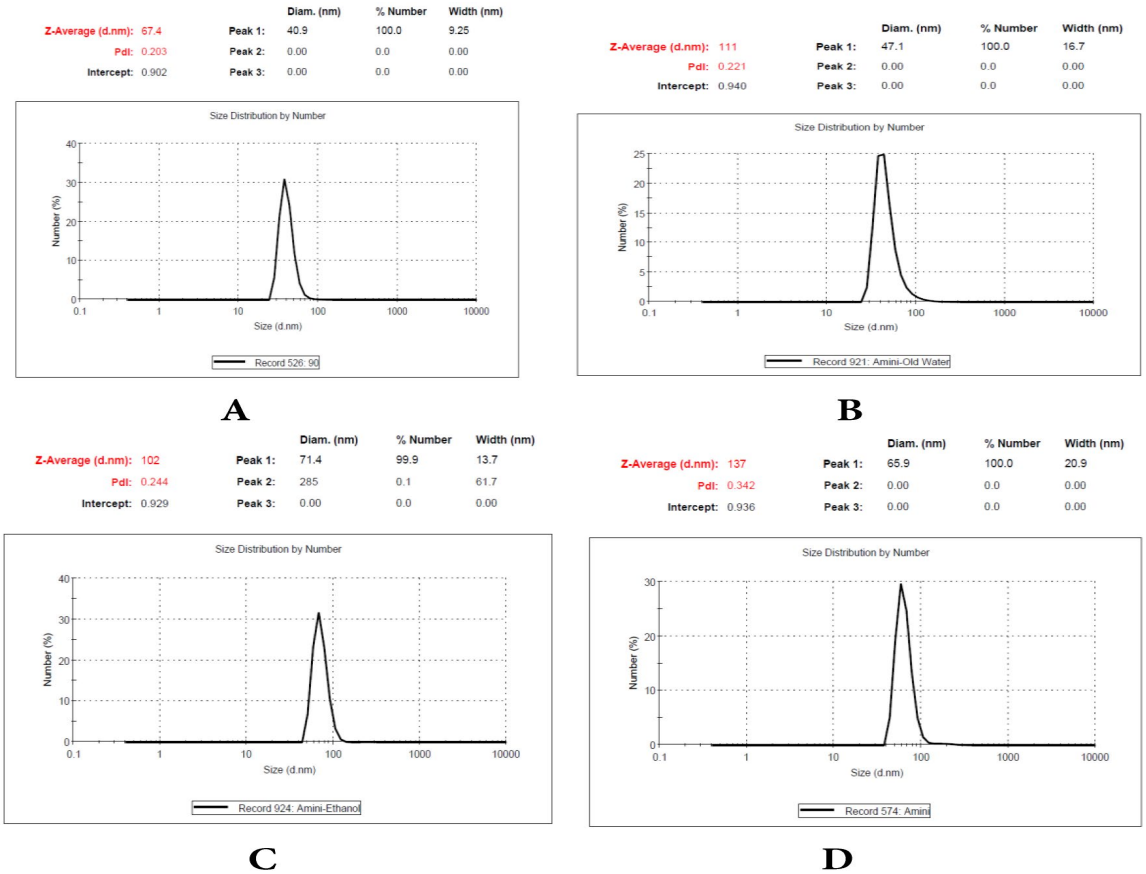

Fig. 4. 1mM hydro-alcoholic extract (A). 1mM aqueous extract (B). 4mM hydro-alcoholic extract (C). 4mM aqueous extract (D).

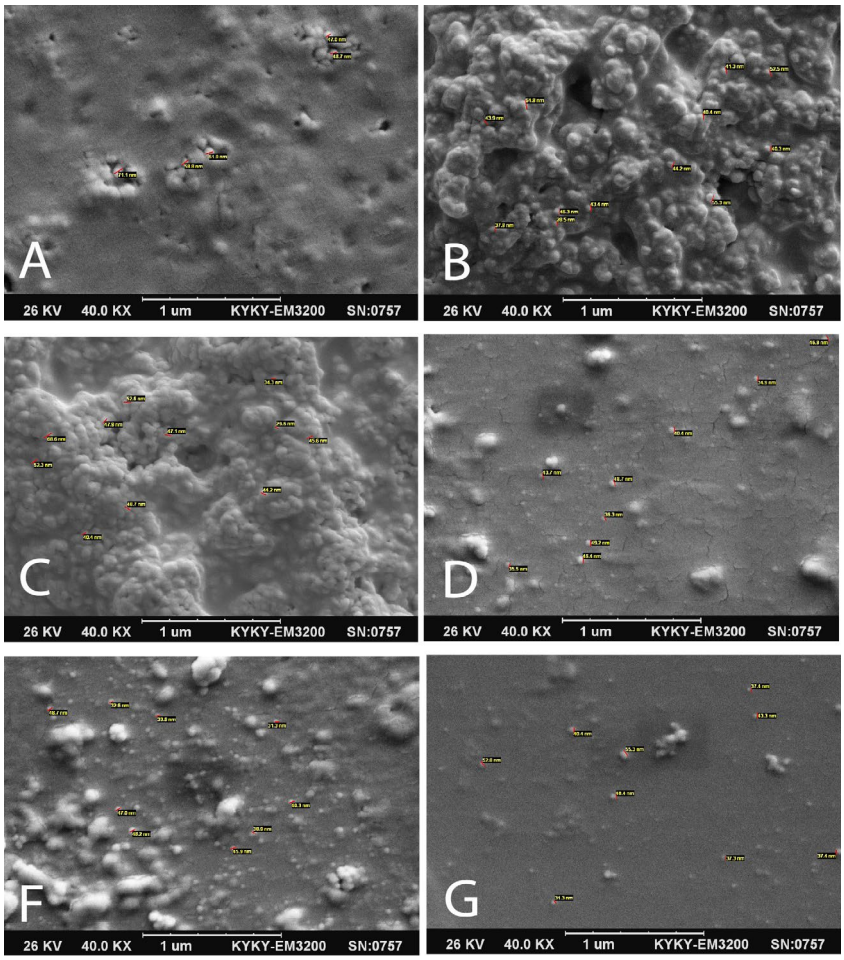

Fig. 5. 1mM hydro-alcoholic extract at 30°C (A). 1m M hydro-alcoholic extract at 60°C (B). 1mM hydro-alcoholic extract at 90°C (C). 1mM aqueous extract at 30°C (D). 1mM aqueous extract at 60°C (F). 1mM aqueous extract at 90°C (G).

Temperature factors investigating

The obtained results show that both in aqueous and hydro-alcoholic extracts by increasing the temperature of the reaction, the prepared nanoparticles sizes would be decreased (Fig 5). which is in agreement with previous studies [18,19]. So, for substrate concentration factor study, investigating on nanoparticles size at 90°C was done. SEM images also showed that the size of the synthesized nanoparticles using aqueous extract was smaller than the synthesized nanoparticles using hydro-alcoholic extract.

Substrate concentration factor investigating

The results of SEM shows that by increasing the concentration of Silver nitrate from 1 to 4 mM in aqueous and hydro-alcoholic extracts, a number of nanoparticles production would increase, but it has not a very impressive effect on the nanoparticles' size (Fig 6) Which is in agreement with previous studies [18,19].

It seems that synthesized nanoparticles using aqueous extract were better than the synthesized nanoparticles using hydro-alcoholic extract in shape and size.

CONCLUSIONS

Silver nanoparticles were synthesized using Avena Sativa L extract. Characterization by UV-Vis, SEM, DLS techniques confirmed the reduction of silver ions to silver nanoparticles. The nanoparticles appeared to be spherical in shape with the smooth surface and the size of the particles varied from 60 to 100 nm. SEM images show that the produced nanoparticles are more or less uniform in size and shape and the agglomeration of the particles is clear. The results showed that:

- by increasing the reaction temperature, the size of the nanoparticles would decrease.

- by increasing the silver nitrate concentration from 1 to 4 mM in aqueous and hydro-alcoholic extracts, the amount of produced nanoparticles would be increased, but won't have a significant effect on its size.

- It seems that synthesized nanoparticles using aqueous extract were better than the synthesized nanoparticles using hydro-alcoholic extract in shape and size.

The green synthesis method is a simple, fast, suitable, ecofriendly and can be potentially applied in different plants' extract to produce different metal nanoparticles. Since, Avena Sativa L. are used as a Pharmaceutical plant remedying plenty of diseases, specially in metabolic diseases remedy, it is recommended more study be done on this plant.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

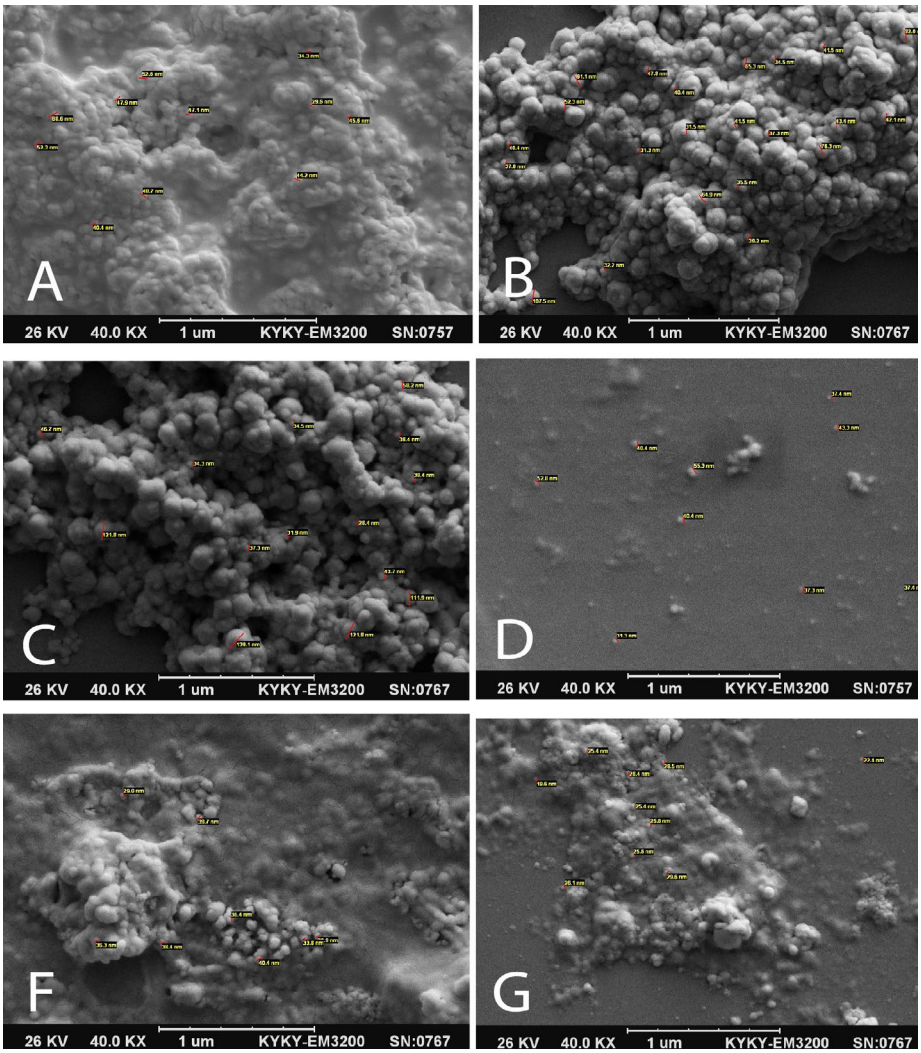

Fig. 6. 1 mM hydro-alcoholic extract at 90°C (A). 2 mM hydro-alcoholic extract at 90°C (B). 4 mM hydro-alcoholic extract at 90°C (C). 1 mM aqueous extract at 90°C (D). 2 mM aqueous extract at 90°C (F). 4 mM aqueous extract at 90°C (G).

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