ORIGINAL RESEARCH PAPER

Investigation of the Effect of Extracts on the Green Synthesis of Silver Nanoparticles

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Received: 2017-07-25 Accepted: 2017-09-23 Published: 2017-12-01

ABSTRACT
Nanoparticles bio production, considering their performance in medicine and biological science, is increasing; also, raising awareness of green chemistry and bioprocesses has encouraged the use of environmentally friendly methods for the production of non-toxic nanomaterials.. Also uses of plant extracts are found to be more advantageous over chemical, physical and microbial (bacterial, fungal, algal) methods for silver nanoparticles (AgNPs) synthesis.
The objectives of this study were the production of silver nanoparticles using aqueous and hydroalcoholic extracts of *Avena sativa L.* an investigation of the effect of extracts on the synthesis of nanoparticles. The morphology and size of the nanoparticles were determined using Scanning Electron Microscope (SEM) and UV-Vis spectroscopy. SEM images showed that the synthesized nanoparticles were mainly spherical and round shaped. The results indicated that synthesized nanoparticles using an aqueous extract were better than the synthesized nanoparticles using hydro-alcoholic extract in shape and size.
Synthesize silver nanoparticles using *Avena sativa L.* Extract provides environmentally friendly option as compared to currently available chemical/ physical methods.

Keywords: *Avena sativa L.; Green Synthesis of Silver Nanoparticles; Aqueous and Hydroalcoholic Extracts*

How to cite this article
Amini N, Amin Gh, Jafari Azar Z. Investigation of the Effect of Extracts on the Green Synthesis of Silver Nanoparticles. J. Nanoanalysis., 2017; 4(3): 223-227. DOI: 10.22034/jna.2017.541269.1013

INTRODUCTION

Nanoparticles bio production, considering their performance in medicine and biological science, is increasing; also, raising awareness of green chemistry and bioprocesses has encouraged the use of environmentally friendly methods for the production of non-toxic nanomaterials. The not harmful biological procedures for non-toxic biological materials nanoparticles could be substituted with the conventional chemical procedure used for nanoparticles production [1, 2].

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Some of the requirements for the green synthesis of nanoparticles include cost reduction, pollution reduction and decrease in side effects, as well as applying in detergent industries, disinfectants and pharmaceuticals. Due to the reduction in production costs, it is possible to industrialize the production of silver nanoparticles for using in the industry. Silver nanoparticles can be used as an antimicrobial [3], anti-cancer [4], Anti-TB [5], catalyst [6,7], biosensor [8], agriculture [9], pests and insects control [10], and targeted drug delivery [11].

It should be noted that D. Singh et al. synthesized silver nanoparticles using *Argemone mexicana* leaf extract, and investigated its antimicrobial activity [3].

Iravani synthesized silver nanoparticles from *Pinus eldarica* bark extract, and also optimized their biosynthesis process [12]. In another study conducted by Miri et al., silver nanoparticles were synthesized using *Prosopis farcta* extract at room temperature. The obtained synthesized nanoparticles at a concentration of 1 mM of $AgNO_3$ solution were spherical with 1.8 nm in diameter [13].

The aim of the present study was to produce the silver nanoparticles using aqueous and hydroalcoholic extracts of *Avena sativa L.*, and to investigate the effect of extracts on the formation of silver nanoparticles.

Experimental

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 water, then with distilled water, dried and powdered and stored for further study.

Plant Extraction

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 refrigerator at 4°C. The extract was used as reducing as well as capping agent.

Hydroalcoholic 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

First, 1 mM silver nitrate was prepared, and then 90 ml was taken from this solution to synthesize the silver nanoparticles. Next, 10 ml of aqueous and hydroalcoholic extracts was added separately to 90 ml of the silver nitrate. The flasks containing the extract and the silver nitrate were separately placed on the hot plate stirrer at a temperature of 90°C.

The color of the solutions was completely changed after 24 hours from yellow to dark brown, showing the synthesis of silver nanoparticles. Eventually, The morphology and size of the nanoparticles were determined using Scanning Electron Microscope (SEM) and UV-Vis spectroscopy. The synthesized nanoparticle solution was centrifuged at 12000 rpm for 15 minutes. The supernatant was removed, the bottom solution was collected in another container, and the remaining solution was placed in an oven at 70°C for 24 hours. After complete removal of the solvent, the remaining material was taken from the bottom of the container; the resulting powder was poured into vials and analyzed by SEM.

RESULT AND DISCUSSION

UV-Vis spectrophotometer

The formation of silver nanoparticles was monitored with color change and UV-Vis spectroscopy. As shown in Figure 1 the color of solutions was completely changed after 24 hours from yellow to dark brown, representing the synthesis of silver nanoparticles due to the reduction of Ag^+ to Ag^0 (silver nanoparticles) by the active molecules present in the *Avena sativa L.* extract.

The following experiments were carried out to confirm the synthesis of silver nanoparticles.

At first, the *Avena sativa L.* extract was placed on stirring heater at 90°C for 24 hours. As shown in part A of Fig. 2 the color change was not observed.

Once again, the extract with silver nitrate was placed at room temperature for 24 hours. As shown in part B of Fig. 2 the color change was not observed.

Finally, the extract with silver nitrate was placed on stirring heater at 90°C for 24h. The appearance of a brownish color confirmed the formation of silver nanoparticles.[12,13].

Fig.1. Color change of solution due to the synthesis of silver nanoparticles.

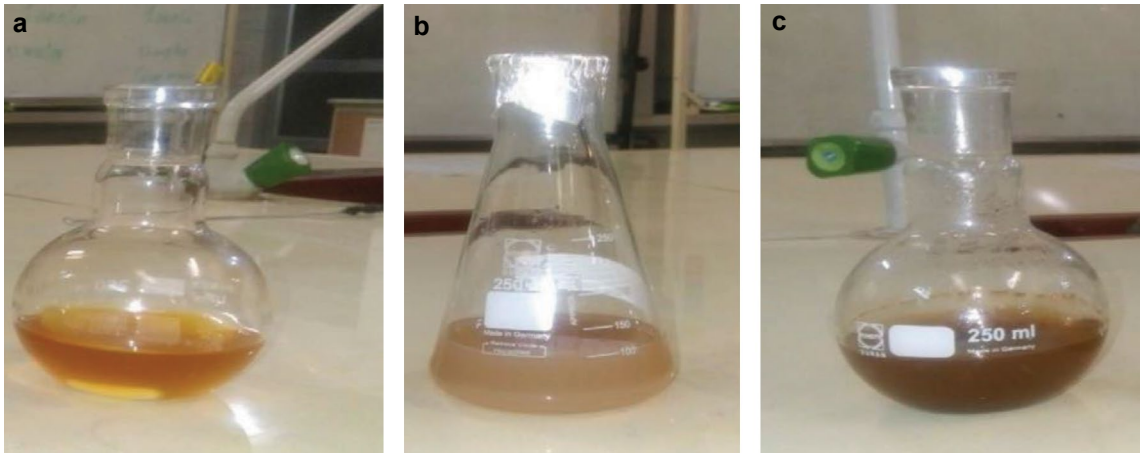

Fig. 2. (a) The crude extract of Avena sativa L. at 90°C for 24 h (b) with $AgNo_3$ at room temperature for 24h (c) and with $AgNo_3$ at 90°C for 24h. The appearance of a brownish color confirmed the formation of silver nanoparticles.

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 4, 5) or too much diluted of the reaction mixture. This case was also seen in Amany A. El-Kheshen et al., 2012 [14] studies they believe that this happened because of agglomeration and decreasing in silver concentration.

For this purpose we have used ultraviolet-visible spectrophotometer, available at Faculty of Pharmacy, University of Tehran (cecil 7500). It should be noted that deionized water was used as a control. It is worth noting that the results for the hydroalcoholic and aqueous extracts were the same as in the following.

SEM analysis

The morphology and size of the synthesized nanoparticles were determined using SEM (KYKY, model EM3200). The SEM images of nanoparticles synthesized are shown in Figures 4 and 5. The synthesized nanoparticles were mainly spherical with the size between 60-100 nm in diameter. The images showed that the synthesized nanoparticles were agglomerates with a low uniformity.

The SEM images indicated that the synthesized nanoparticles using aqueous extract are smaller than the nanoparticles synthesized using hydroalcoholic extract. Our results are consistent with the findings of previous investigations [12,13].

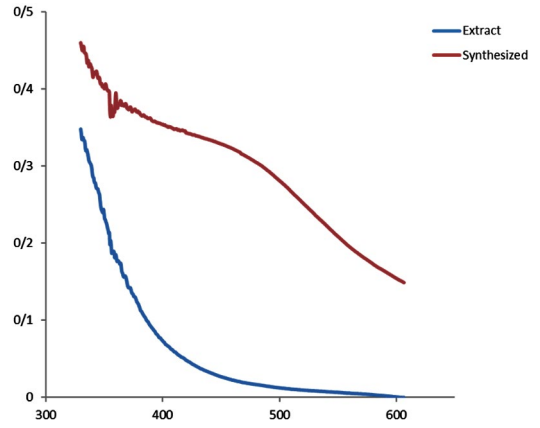

Fig. 3. Spectra for the spectrophotometric analysis of the extract and solution of the synthesized nanoparticles.

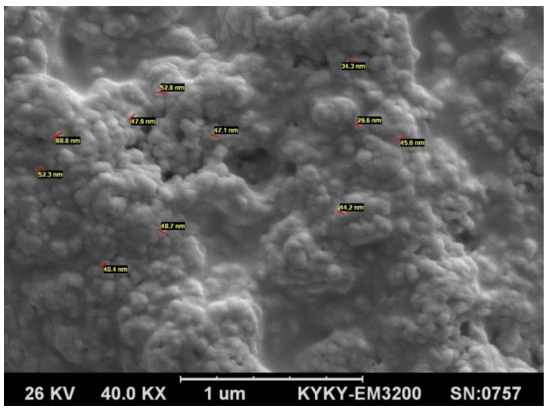

Fig. 4. 1 mM hydroalcoholic extract at 90°C.

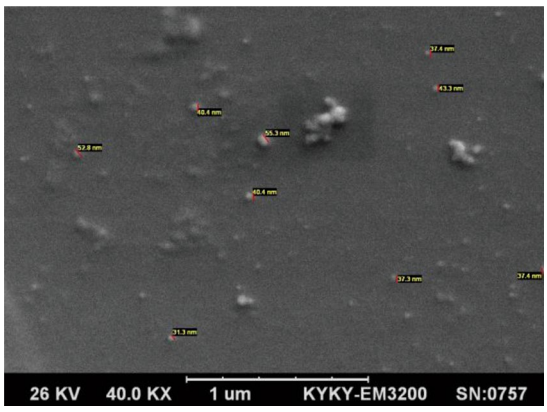

Fig. 5. 1 mM aqueous extract at 90°C.

CONCLUSION

The aim of this study was to investigate the effect of extracts on the green synthesis of silver nanoparticles. In This study silver nanoparticles were synthesized using aqueous and hydroalcoholic extract of *Avena sativa L.* The morphology and size of the nanoparticles were determined using Scanning Electron Microscope (SEM) and UV-Vis spectroscopy. The synthesized nanoparticles according to the SEM images were mainly spherical and round shaped with the size between 60-100 nm in diameter. Moreover, the images indicated that the synthesized nanoparticles were agglomerates with a low uniformity. The results indicated that synthesized nanoparticles using aqueous extract were better than the synthesized nanoparticles using hydro-alcoholic extract in shape and size.

The aspect of innovation of this study, in comparison with the past studies, is that the use of *Avena sativa L.* for green synthesis of silver nanoparticles is undocumented. Also the effect of extracts on green synthesis of nanoparticles using this plant has not been checked. Since *Avena sativa L.* is low cost and abundant plant in Iran and preparation of its aqueous extract is simple and cost effective, use of this plant for green synthesis is very affordable.

Overall, the green synthesis is a simple, fast, suitable and environmentally friendly approach. For this reason, various plant extracts can be exploited in the synthesis of various nanoparticles. Furthermore, since *Avena sativa L.*, as the herbal medicine, is effective in the treatment of many diseases, especially in the treatment of metabolic diseases, so further studies are suggested to be conducted on this plant and also study on other factors to achieve ideal conditions in order to increase the reaction efficiency and synthesize smaller nanoparticles.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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