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Green synthesis of least agglomerated highly stable silver NPs using the optimal aqueous extract of the *Moringa olifera* seeds

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Abstract

Through this research, the optimal aqueous extract of the seeds of the *Moringa olifera* was used to biosynthesis of least agglomerated highly stable silver nanoparticles. The optimum extraction parameters such as PH, time of extraction, temperature and material ratio were considered to obtain the maximum content of flavonoid antioxidants as bioreducers to biosynthesis of Ag NPs. Further, the green synthesized silver nanoparticles by this method showed a very good stability and crystalinity which referes to the highly concentration of antioxidant phenolics through optimum extraction process and also minimum agglomeration rather than previouse reported works.

Keywords: *Extraction parameters, Antioxidant flavonoids, Moringa olifera* seeds, highly stable silver nanoparticles

1. Introduction

Moringa olifera from the family of *Moringaceae* is an edible plant cultivated in different countries of Middle East such as Iran, Iraq and Pakistan. The seeds of the plant is one of the best green sources of vitamins, minerals, and potent anti-oxidants such as flavonoid compounds, Figure 1. In fact the different parts of the plant are used as herbal drugs to relieve many human deficiencies and sicknesses such as vitamins and minerals deficiencies, cardiovascular defect and promoting normal blood-glucose levels for its pharmaceutical properties such as anit-flammatory, antioxidant and antimicrobial effects. It also improves eyesight, mental alertness and bone strength, [1-3]. The seeds of *Moringa olifera* use in food making after boiling to remove its bitter test and prepare the dried nuts and other food beverages. Furthermore, the application of different parts of this shrub in folk medicine is common among the local people for remedy of leprosy, rheumatism, stomach ulcer and antidote, [4, 5]. Recently the plants containing antioxidant phytochemicals were attracted the interest of many researchers in which some reports concerning the biosynthesis of nanostructures using green methods especially plant sources emphasized on the antioxidant content of the plants extract as bioreducers and stabilizing agents, [6-12].

Figure1. Image of the *Moringa olifera* seeds

In our previous work, the optimum extraction conditions of flavonoids from the seeds of *Moringa olifera* was investigated using colorimetric Emerson reaction. Also, the antioxidant activity of the optimized plant extract compared to the other plant seeds extracts with different polarities was evaluated using FRAP method, [13]. Therefore, in continuation of our work, through this study the optimum extract of the seeds of *Moringa olifera* containing the maximum antioxidant content is used to green synthesis of highly stable silver nanoparticles with minimum agglomeration.

2. Materials and methods

All reagents and materials used in this process are from Aldrich. All solutions were prepared with water that was doubly distilled. Glass apparatus and vessels were cleaned by soaking in 10% HNO_3 followed by rinses with distilled water.

2.1. Plant material

The seeds of *Moringa olifera* were collected in July 2014 at Nikshahr region at Sistan and Baluchestan province from Iran. Voucher specimen was deposited at the herbarium of department of biology at university of Sistan and Baluchestan.

2.2. Optimum extrac of the Moringa olifera seeds

After studying the optimum extraction parameters to obtain the maximum percent of antioxidant flavonoids in the plant extract [13], 20 g of the plant seeds powder dissolved in 100 mL distillated water at 80°C for 60 min while stirring at neutralized pH. The obtained extract then was filtered and kept in refrigerator for more application.

3. Results and Discussions

3.1. Spectroscopic results for the plant extract

Figure 2 shows bonds at 300 nm (bond I) and 225 nm (bond II) assigned to the cinnamoyl and benzoyl phenolic systems. In fact, these signals are related to the $\pi \rightarrow \pi^*$ transitions which demonstrate the presence of phenolics as antioxidant source for green synthesis of nanoparticles, [14-16].

3.2. Biosynthesis of highly stability Ag NPs

50 mL of the optimum plant extract was added dropwise to 50 ml of 0.005 M aqueous solution of $AgNO_3$ under reflux condition at 80 °C until changing the color of the mixture to brown due to surface plasmon resonance around 480 nm showing the formation of Ag NPs. Reduction of Ag^+ to Ag^0 was completed in 5 min (as monitored by UV-vis spectra). The biosynthesized sliver nanoparticles using the optimal extract are almost quite stable even after 3 weeks, Figure 2. This time of stability demonstrate the maximum concentration of antioxidant inside the plant extract which adsorbed on the surface of nanoparticles and protect the nanoparticles from decompositions and deformation processes.

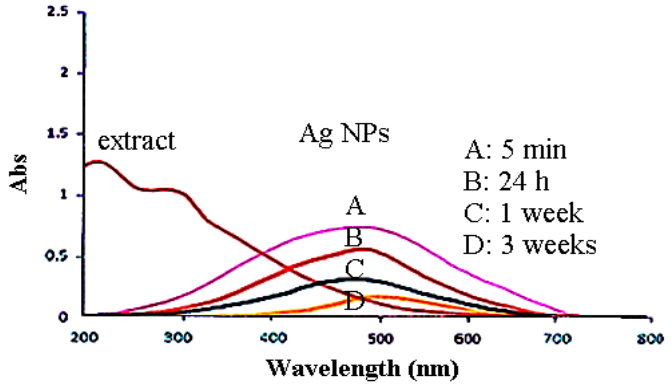

Figure 2; Uv-vis spectra of plant extract and biosynthesized Ag NPs

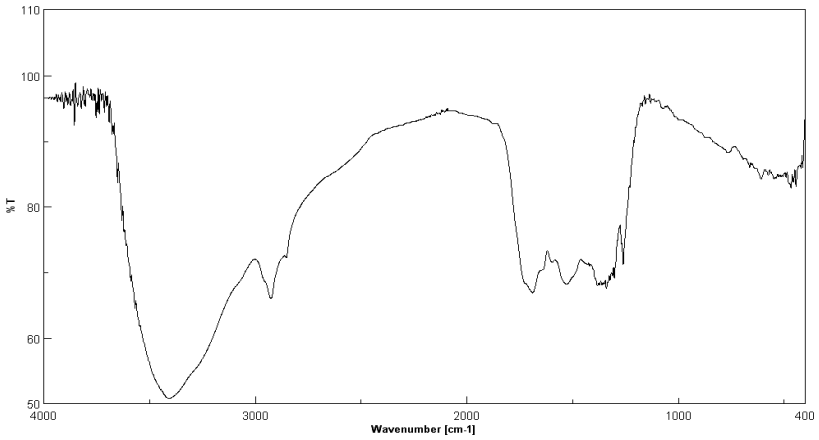

Figure 3; FT-IR spectrum of the green synthesized Ag NPs

Also, to confirme the adsorption of phytochemicals on the surface of green synthesized Ag NPs the FT-IR technique was used. As figure 3 shows, the signals at 3400, 1690, 1500 and 1000 to 1300 $cm^{-1}$are assigned to OH, carbonyl, aromatic C=C and C-O functional groups, respectively. Therefore, the FT-IR spectrum strongly confirmed the adsorption of phytochemicals on the Ag nanosurface following its green synthesis. The XRD analysis demonstrate some peaks of 2theta values of 34.3, 43.11, 64.2, 75.3 and 84.0 degrees, which are assigned to the corresponding 111, 200, 220, 311 and 222 indices of the face centered cubic (fcc) lattice of metallic Ag, Figure 4.

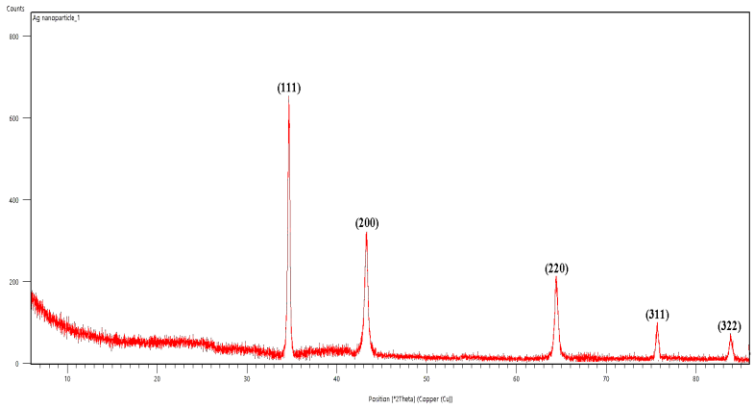

Figure 4; XRD pattern of the green synthesized Ag NPs

The TEM micrograph, of Ag NPs shows the morphology and size of Ag NPs. As shown in Fig. 5, it seems that the Ag NPs are semispherical with some agglomerations of the particles further the average size of green synthesized Ag(0) NPs is around 30 nm. Furthermore, according the reported literatures [10-15], the agglomeration process of nanoparticles especially silver nanoparticles are a main problem during their synthesis which studies are still continued to decreasing this process. As figure 5 is shown, the TEM micrograph clearly demonstrated the minimum agglomeration of Ag NPs which probably is due to the adsorption of maximum antioxidant flavonoids on its nanosurface while its biosynthesis using optimum plant seeds extract.

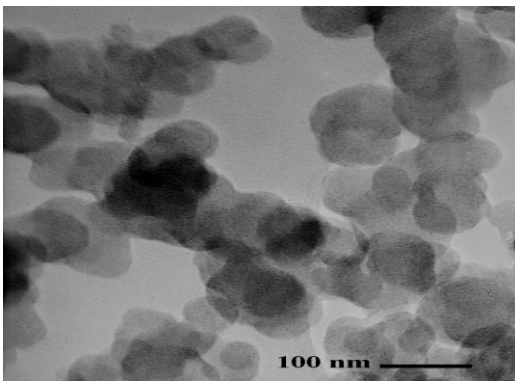

Figure 5; TEM image of green synthesized Ag NPs

4. Conclusion

A highly antioxidant extract was obtained from the seeds of *Moringa olifera* using the obtained optimum extraction parameters as 20 g plant seed powder mixed to 100 mL distillated water at 80°C for 60 min at pH 7. The optimal extract showed strong antioxidant activity as demonstrated with FRAP method compared to the other types of crude

extracts with different polarities in which it probably referred to the high concentration of antioxidant flavonoids of the optimum extract. Further, the green synthesized silver nanoparticles by this method showed a very good stability and crystalinity which referes to the highly concentration of antioxidant phenolics through optimum extraction process.

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