JOURNAL OF PURE AND APPLIED MICROBIOLOGY, May 2014. Vol. **8**(Spl. Edn. 1), p. 227-231

Green Synthesis and Characterization of Silver Nanoparticles using *Malva parviflora* Aqueous Extract

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(Received: 27 January 2014; accepted: 03 April 2014)

There is an increasing need to develop high-yield, low cost, non-toxic and eco-friendly procedures for the synthesis of nanoparticles. Silver nanoparticles (AgNPs) synthesized through bio-green method has been reported to have biomedical applications to control pathogenic microbes as it is cost effective compared to commonly used methods. In the present study AgNPs were synthesized from aqueous silver nitrate through a simple and eco-friendly route using leaf broth of *Malva parviflora*, which acted as a reductant and stabilizer simultaneously. The formation of AgNPs was observed by the change of color from colorless to dark brown by the addition of silver nitrate into leaves extract. The synthesized AgNPs were characterized by UV–Vis spectrophotometer analysis. The expected reaction mechanism in the formation of AgNPs is also reported. This process of synthesis creates new opportunities in process development for the synthesis of AgNPs

Key words: Silver Nanoparticles, *Malva parviflora*, UV–Vis.

Nanoscience and nanotechnology has seen major development in the bio-fabrication process of metal nanoparticles (MNPs)[1]. The MNPs are broadly applied in the science and technology such as medicine, biology, biotechnology, chemistry, physics, and catalysis, electronics and material sciences. Silver nanoparticles (AgNPs) have drawn intensive interest in recent years due to the low-cost, high-efficiency, unique optical and electronic properties which lead to potential applications in industrial fields such as catalyst[2], antimicrobial agents[3], conductive coating and sensors[4]. Currently, a large number of physical, chemical, biological, and hybrid methods are available to synthesize different types of nanoparticles[5]. Though physical and chemical methods are more popular for nanoparticle synthesis, the use of toxic compounds limits their applications. To overcome the problem of toxicity in synthesis, safe eco-friendly green methods have a major role for producing nanoparticles[6]. Several methods have been used for the green biosynthesis of NPs using various biological materials as reducing agents such as microorganisms, marine

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organisms, micro-fluids, and plant extracts[7]. The bio-green method of synthesizing nanoparticles using either microorganisms or extracts of medicinal plants holds unique attention among researchers. It is an economic, eco-friendly and simple method in the synthesis route[8]. Synthesis of nanoparticles using microorganisms[9] consume more time for the maintenance of microorganisms whereas the plant extract mediated methods require less processing time. Plant extracts, are relatively easy to handle, readily available, low cost, and have been well explored for the green synthesis of other nanomaterials[10]. Moreover, the biologically active molecules involved in the green synthesis of NPs act as functionalizing ligands, making these NPs more suitable for biomedical applications[11].

Malva parviflora, a prostrate perennial herb, with a deep strong tap root system, found in Europe, has become a cosmopolitan weed species in gardens throughout Egypt[12]. The whole herb show healing properties and externally used in resolving boils, abscesses and removing splinter tissue. Anti-inflammatory, antimicrobial, antioxidant and wound healing abilities have been reported[13]. Mervat *et al.* 2012 have studied five plant leaf 70% ethanolic extracts (*Malva parviflora*, *Beta vulgaris* subsp. Vulgaris, *Anethum graveolens*, *Allium kurrat* and *Capsicum frutescens*) were screened for their bioreduction behavior for synthesis of silver nanoparticles. *M. parviflora* (Malvaceae) was found to exhibit the best reducing and protecting action in terms of synthesis rate and monodispersity of the prepared silver nanoparticles[14].

Hence, the present study was designed to prepare AgNPs using bio-green method with aqueous extract of *Malva parviflora* bioreducing agent of Ag^+ to Ag to synthesize the silver nanoparticles. The formed AgNPs were characterized using ultraviolet-visible spectroscopy. Understanding of the in situ particle stabilization mechanism are focused in this study

MATERIALS AND METHODS

All chemicals used in the present study are of high purity and are obtained from Sigma and Merck. All glassware's were washed with HNO_3 and distilled water and dried in oven. *Malva parviflora* were collected from local area of Riyadh, Saudi Arabia.

Preparation of leaf extract

The fresh plant leaves (Fig. 1) were washed several times with running tap water, and then with distilled water. 20 g of leaves were weighed and boiled for 15 min in 100 ml Milli-Q water and then the extracts were filtered through Whatman filter paper No. 1. The filtered extract was stored in refrigerator at 4°C. This extracts were used as reducing as well as stabilizing agent

Fig. 1. *Malva parviflora* leaves

Bio-green synthesis of silver nanoparticles

The synthesis of nanoparticles by bio-green method was carried by adding 10 ml of *Malva parviflora* aqueous extract (Fig. 2a) to 50 ml of 1 mM silver nitrate solution and kept for incubation at room temperature for 2 h. The overall reaction

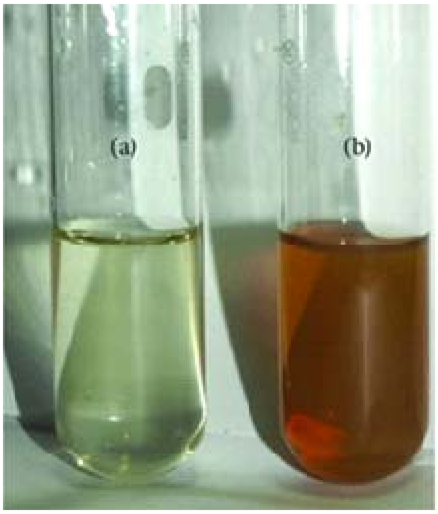

Fig. 2. Biosynthesis of AgNPsusing *Malva parviflora* leaves visible observations: (a) plant extract (b) silver nanoparticles

process was carried out in dark to avoid unnecessary photochemical reactions. The color change of the silver nitrate solution from colorless to brownish yellow was observed by naked eye (Fig. 2b) and the bio reduced sample component was confirmed by UV–Visible spectroscopy. The obtained *Malva parviflora* AgNPs were purified through repeated centrifugation at 11,500 rpm for 20 min and washed with distilled water. The *Malva parviflora* AgNPs were collected and redispersed in deionized water for characterization.

UV–visible spectroscopy

The formation of AgNPs from silver ions at different time intervals was monitored by measuring the UV–visible spectra of the respective solutions after diluting it 20 times with deionized water. The spectrum was recorded by using UV-1700 Shimadzu UV–Visible spectrophotometer from 300 nm to600 nm. The deionized water was used as the blank.

RESULTS AND DISCUSSION

Silver nanoparticle preparation and characterization

The characterization and measurements of the AgNPs produced by the green reduction method using the *Malva parviflora* extract are presented. The effects of the reaction time, mechanism of the formation of the AgNPs and the influence of the essential functional groups involved in reducing the silver ions to nanoparticles, have been considered, and are discussed in the following sections.

Formation of AgNPs from 1 mM solution of silver nitrate and *C. collinus* filtrate can be easily visualized by the color change of the mixture which is turned from green to yellowish brown color as shown in Fig. 2 It is well known that AgNPs shows a yellowish brown color in aqueous solution; this color arises from excitation of surface plasmon vibrations in the metal nanoparticles[24,25] it is due to collective oscillation of free electrons present in the reducedAgNPs[39]. Such visual observations on a change in biomass color due to the synthesis of gold nanoparticles have been reported earlier[15].

UV–visspectroscopy is usually the first technique which is used in characterization of metallic nanoparticles because of surface plasmon resonance (SPR) phenomenon[16]. Fig. 3 shows the UV–vis absorption spectra of the Ag nanoparticles at different time intervals. Typical AgNPs having λmax values which are in the visible range of 400–500 nm[17]. The absorption peak of obtained AgNPs is centered around 410-430 nm. This observation clearly indicates the successful reduction of Ag using *Malva parviflora* extract. Surface Plasmon peak observed confirms the influence of aqueous *Malva parviflora* leaf extract in reducing Ag^+ ions to Ag NPs from aqueous $AgNO_3$ solution. The formation of AgNPs was found to increase with reaction time. The broad spectra formed at short time indicate the presence of particles with a broad size distribution. There is a slight shift in the peak towards shorter wavelength with time observed. This shift may be attributed to slight modification in the size and shape of nanoparticles[18]. From the figure it is observed that the absorption peak becomes sharp as the time increases. This indicates the formation of the poly dispersed AgNPs initially that become mono-dispersed spherical nanoparticles with increasing reaction time. Thus

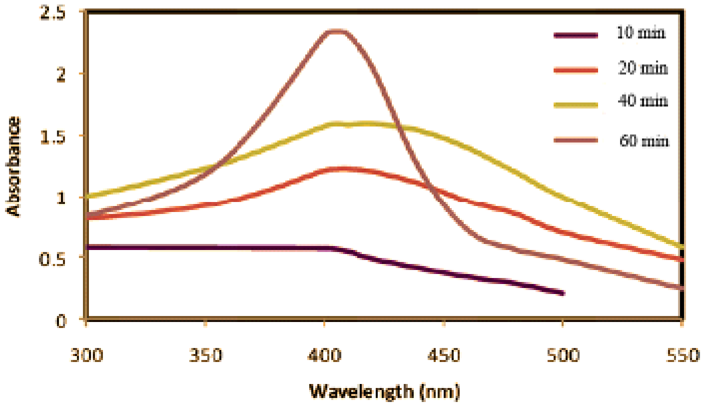

Fig. 3. UV- vis spectra of AgNPs synthesized by *Malva parviflora* leaves at different time intervals

from the results it can be inferred that at room temperature the mixing time is an important factor in determining the size distribution of silver nanoparticles.

Mechanism of the formation of silver nanoparticle

The bioactive compounds like alkaloids, flavanoids, tannias, ascorbic acid and phenolic compounds are present in plant. The probable mechanism for the reduction of Ag^+ is proposed and presented in Fig. 4. In this scheme, Ag^+ ions can form intermediate complexes with phenolic OH

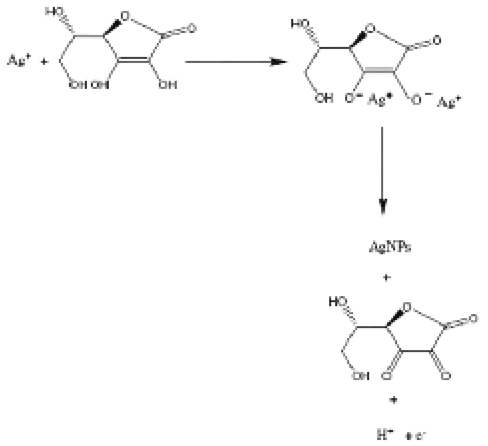

Fig. 4. Possible mechanism for silver nanoparticle formation[19]

groups present in hydrolysable tannins which consequently undergo oxidation to ascorbic acid forms with ensuing reduction of Ag+ to AgNPs[19].

CONCLUSION

Nano size metals have brought a new revolution to the modern era of science; particularly AgNPs have been exploited in various fields of chemistry, physics, biology and medicine. In conclusion we introduce a simple, fast, and economical biological procedure to synthesize Ag nanoparticles using *Malva parviflora* leave extract. Plant extract was usedas a reducing and capping agents. The characterization of Ag+ ions exposed to this plant extracts by UV-vis techniques confirm the reduction of silver ions to silver nanoparticles. The presence of phenolic compounds may be the key factors for the formation of silver nanoparticles. Biological synthesized AgNPs could be of immense use in the medical field for their efficient antimicrobial function.

ACKNOWLEDGMENTS

This project was supported by King Saud University, Deanship of Scientific Research, College of science Research Centre.

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