Journal of Saudi Chemical Society (2014) **18**, 356–363

King Saud University

Journal of Saudi Chemical Society

www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Antioxidant and antibacterial activity of silver nanoparticles biosynthesized using *Chenopodium murale* leaf extract

Mohamed S. Abdel-Aziz [a], Mohamed S. Shaheen [b], Aziza A. El-Nekeety [c], Mosaad A. Abdel-Wahhab [c,*]

[a] *Microbial Chemistry Department, National Research Center, Dokki, Cairo, Egypt*
[b] *Flavour & Aroma Department, National Research Center, Dokki, Cairo, Egypt*
[c] *Food Toxicology & Contaminants Department, National Research Center, Dokki, Cairo, Egypt*

Available online 6 October 2013

KEYWORDS

Chenopodium murale;
Silver nanoparticles;
Antioxidant;
Antimicrobial;
Nanotechnology

Abstract Silver is known for its antimicrobial effects and silver nanoparticles are gaining their importance due to their antimicrobial activities. The aims of the current study were to use plant extract for the biosynthesis of silver nanoparticles and to evaluate their antibacterial and antioxidant activity *in vitro*. The results indicated that silver nanoparticles (AgNPs) can be synthesized in a simple method using *Chenopodium murale* leaf extract. The TEM analysis showed that the sizes of the synthesized AgNps ranged from 30 to 50 nm. The essential oil of *C. murale* leaf extract was formed mainly of α-Terpinene, (*Z*)-Ascaridole and *cis*-Ascaridole. The total phenolic compounds and total flavonides were higher in AgNPs-containing plant extract compared to the plant extract. AgNPs-containing leaf extract showed a higher antioxidant and antimicrobial activity compared to *C. murale* leaf extract alone or silver nitrate. It could be concluded that *C. murale* leaf extract can be used effectively in the production of potential antioxidant and antimicrobial AgNPs for commercial application.

1. Introduction

The synthesis of noble metal nanoparticles attracts an increasing interest due to their new and different characteristics as compared with those of macroscopic phase, that allow attractive applications in various fields such as antimicrobials [48], medicine, biotechnology, optics, microelectronics, catalysis, information storage and energy conversion [71]. Silver nanoparticles (AgNPs) have the properties of high surface area, very small size (< 20 nm) and high dispersion [40]. Silver is a safe and effective bactericidal metal because it is non-toxic to animal cells and highly toxic to bacteria [33,38,72]. Silver

* Corresponding author. Tel.: +20 2 2283 1943; fax: +20 2 3337 0931.
E-mail address: mosaad_abdelwahhab@yahoo.com (M.A. Abdel-Wahhab).

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

1319-6103 © 2013 Production and hosting by Elsevier B.V. on behalf of King Saud University. Open access under CC BY-NC-ND license.
http://dx.doi.org/10.1016/j.jscs.2013.09.011

nanoparticles (AgNPs) are one of the most commonly used nanomaterials. AgNPs are known to have antioxidant and antimicrobial properties [1]. AgNPs are used in coating or embedding for medical purposes [70]. In addition to their medical uses, AgNPs are also used in clothing, food industry, paints, electronics and other fields [15,37,66]. Several techniques have demonstrated that AgNPs can be synthesized using chemical and physical methods, but due to the fact of usage of a huge amount of toxic chemicals and high temperature conditions, it becomes a mandate to find an alternative method [49].

Green chemistry approach emphasizes that the usage of natural organisms has offered a reliable, simple, nontoxic and eco-friendly [43,54]. Therefore, researchers in the last years have turned to biological systems for nanoparticle synthesis [64]. Synthesis of nanoparticles by biological methods, using microorganisms, enzyme and plant or plant extract, has been suggested as possible eco-friendly alternatives to chemical and physical methods [56,42]. Biosynthesis of nanoparticles by plant surpasses other biological methods by reducing the complicated process of maintaining cell culture [69].

A plant species *Gliricidia sepium* used for the synthesis of silver nanoparticles, showed an absorption maximum at 440 nm [51]. Green synthesis of AgNPs using *Argimone maxicana* leaves broth generated particles of 20 nm and was found to be effective against many bacterial and fungal pathogens [30]. *Cycas* leaf extract was used to prepare silver nanoparticles of 2 to 6 nm [29]. A plant species *Solanum torvum* produced AgNPs of 14 nm dimension and showed the absorbance peak at 434 nm. The antimicrobial activity of synthesized nanoparticles was tested against *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Aspergillus flavus* and *Aspergillus niger*, showing a zone of inhibition [22]. Weeds such as *Ipomoea aquatica*, *Enhydra fluctuans* and *Ludwigia adscendens* were used as precursors for the synthesis of AgNPs that showed an absorbance peak between 400 and 480 nm [53]. AgNPs synthesized from *Boswellia ovalifoliolata* stem bark showed UV–Vis analysis absorption maxima at 430 nm and their size varied from 30 to 40 nm [6]. Dried leaves of *Cinnamomum camphora* have been implicated in the synthesis of 55–80 nm of AgNPs [26]. *Emblica officinalis* fruit extract was used for fabrication of gold and silver nanoparticles of 10 nm, showed a maximum absorption of light at 430 nm [5]. *Eucalyptus hybrida* (Safeda) leaves have been shown to synthesize AgNPs of 50 nm [16]. Dried leaves of *Pongamia pinnata* (L) Pierre were used to synthesize AgNPs of 20 nm size with an antimicrobial activity against many gram negative and gram positive microorganisms [52]. Bio-reduction of silver using various plant extracts such as *Helianthus annus*, *Basella alba*, *Oryza sativa*, *Saccharum officinarum*, *Sorghum bicolor* and *Zea mays* have been studied by Leela and Vivekanandan [36]. Leaf extract of *Parthenium hysterophorus* synthesized AgNPs of average size of 50 nm [46]. An aqueous extract of *Azadirachta indica* (Neem) leaves too was studied for the biogenic synthesis of AgNPs, showed a maximum absorbance between 440 and 500 nm [41]. *Chenopodium murale* (Nettleleaf goosefoot) is one of the fast-growing annuals of the family Chenopodiaceae and is widespread throughout different habitat types in Egypt [34,57]. It was introduced from Europe and grows best in moist soil. It is an abundant winter to early summer weed and is considered a pest in agroecosystems, roadsides, and waste places. Field observations reveal the failure of some other plant species to establish within pure patches of *C. murale*, as proved by its negative association pattern with many weeds and cultivated species in some community types [19,20]. The hypothesis is that several factors together determines the nanoparticle synthesis, including the plant source, the organic compounds in the crude leaf extract, the concentration of silver nitrate, the temperature and other than these, even the pigments in the leaf extract. Consequently, the longtime aims are to identify those compounds in *C. murale* grown in Egypt and to investigate their efficiency to reduce silver ions as well as the formation of silver nanoparticles. The aims of the current study were to utilize for the first time the *C. murale* grown in Egypt to (1) evaluate the chemical composition, antioxidant activity, total phenolic content and total flavonoids of the plant (2) synthesis of silver nanoparticles using the leaf extract of *C. murale* and (3) evaluate the antibacterial activity of the plant extract alone or with the plant nanosliver.

2. Materials and methods

2.1. Plant materials

The leaf of *C. murale* (Family: Chenopodiaceae) was collected from the Dekernis District, Dakahlia governorate, Egypt during December 2011 and January 2012 (Fig. 1).

2.2. Biosynthesis of AgNPs

The fresh leaf extract used for the biosynthesis of AgNPs was prepared from 20 g of thoroughly washed leaf in a 500 ml Erlenmeyer flask, boiled in 50 ml distilled water for 30 min and the produced extract was subjected to freeze drying. Suspensions were filtered with Whatman No. 40 filter paper [17]. Fifty ml of 5×10^{-3} M aqueous solution of silver nitrate was prepared in a Stoppard Erlenmeyer flask and 1 ml of leaf extract (0.2 g/ml) was added at room temperature for 24 h in the dark until the brownish color was developed which indicated the formation of AgNPs [46].

2.3. Characterization of AgNPs

2.3.1. UV–vis adsorbance spectroscopy analysis

The bioreduction of silver nitrate ($AgNO_3$) to AgNPs was monitored periodically by UV–vis spectroscopy (Shimazu 2401PC) after the dilution of the samples with deionized water [51]. A UV–vis spectrograph of the silver and nanoparticles was recorded by using a quartz cuvette with water as reference. The UV–vis spectrometric readings were recorded at a scanning speed of 200–800 nm [36].

2.3.2. TEM analysis of AgNPs

The suspension containing AgNPs of *C. murale* was sampled by TEM analysis using JEOL model 1200 EX electron microscope. TEM samples were prepared by placing a drop of the suspension of AgNP solutions on carbon-coated copper grids and allowing water to evaporate. The samples on the grids were allowed to dry for 4 min. The shape and size of silver