

Research Article

Phytosynthesis of Cadmium Oxide Nanoparticles from *Achillea wilhelmsii* Flowers

Javad Karimi Andeani and Sasan Mohsenzadeh

Department of Biology, Faculty of Science, Shiraz University, Shiraz 71454, Iran

Correspondence should be addressed to Javad Karimi Andeani; jkandeani@yahoo.com

Received 17 June 2012; Accepted 23 July 2012

Academic Editor: Kevin Shuford

Copyright © 2013 J. Karimi Andeani and S. Mohsenzadeh. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

The study here deals with the plant synthesis of cadmium oxide nanoparticles using flowers extract of *Achillea wilhelmsii* as the reducing agent. The photosynthesis is carried out at room temperature in the laboratory ambience. The aqueous cadmium ions when exposed to flower extract were reduced and resulted in their nanoparticles. The synthesized nanoparticles were characterized using techniques such as scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FTIR), and UV-visible absorption spectroscopy. Stable cadmium oxide nanoparticles were formed by treating aqueous solution of cadmium chloride (CdCl_2) with the plant flower extracts as reducing agent.

1. Introduction

In the field of nanotechnology, development of rapid, simple, cost-effective, and ecofriendly procedures for the synthesis of nanoparticles is worth. Furthermore, the improvement of experimental processes for the synthesis of these nanoparticles of different sizes, shapes, and controlled dispersity has many important [1]. These factors strongly affected of the physical and chemical properties and their potential application in optoelectronics [2, 3], electronic [4, 5], recording media [6], sensing devices [7, 8], catalysis [9], biomolecular detection [10], and medicine [11, 12]. To now, several methods have been reported for the synthesis of nanomaterials. However, biological synthesis of nanoparticles has received extensive interest due to chemical methods that are capital intensive, toxic, and have low productivity [13]. Several biological methods using microorganisms (including bacteria, fungi, actinomycetes, and yeast), enzymes, and plants or plant extracts have been suggested. But production of nanoparticles using plants has drawn attention of scientists because of its rapid, economical, eco-friendly protocol and it provides a single-step technique for the biosynthesis process [14]. Biosynthesis of nanoparticles can be categorized into intracellular and extracellular synthesis according to the place where nanoparticles are formed. The extracellular synthesis

is more preferred over intracellular because extracellular synthesis makes the downstream processing less laborious and also is effective in cost-cutting of the entire process during industrial applications [15]. The use of environmentally benign materials like plant leaf and flower extract, bacteria, and fungi for the synthesis of nanoparticles offers numerous benefits of compatibility for pharmaceutical and biomedical applications as they do not use toxic chemicals in the synthesis protocols [16–18]. In contrast with noble metals, such as silver and gold, the synthesis of cadmium (Cd) nanoparticles is much more challenging, since these nanoparticles are fairly unstable in aqueous solution. However, cadmium oxide (CdO) nanoparticles cost significantly less than silver and gold; therefore, these are economically attractive. When cadmium nanoparticles are exposed to air, surface oxidation occurs and ultimately aggregation appears in a short time [19]. Oxide nanomaterials applied as catalysts and starting materials for preparing highly developed structural ceramics [20]. CdO as important semiconductor has promising applications in catalysts [21], sensors [22], solar cells [23], and other optoelectronic devices [24–26]. In the present study, a simple, rapid and green biosynthetic method using *Achillea wilhelmsii* plant has been investigated for producing cadmium oxide nanoparticles. To the best of our knowledge, the exploitation of phytosynthesis of



FIGURE 1: Flower of *A. wilhelmsii* plant.

CdO nanoparticles using plant is so far unexplored and underexploited. Phytosynthesis of cadmium oxide nanoparticles from *Achillea wilhelmsii* flowers is carried out at room temperature and it is advantageous over chemical and physical procedures as it is a cost effective, economic, and environmentally friendly method, where it is not necessary to use high pressure, time, energy, temperature, and toxic chemicals.

2. Experimental Details

2.1. Biosynthesis of CdO Nanoparticles. Flowers of *Achillea wilhelmsii* plants (Figure 1) were used to make the aqueous extract. About 25 gram of the flowers was thoroughly washed in distilled water for 15 min, air-dried, and cut into fine pieces. The pieces were boiled in an Erlenmeyer flask with 100 mL of sterile distilled water for 10 min in order to remove the dust particles. Flower broth was sterilized by filtration ($0.45\ \mu\text{m}$) and kept at 4°C for further experiments and used within a week. In a typical experiment, 25 mL of broth was added to 25 mL of 10 mM aqueous cadmium chloride (CdCl_2) solution and incubated at room temperature. After few minutes, the culture solution was observed to have distinctly deposited precipitate at the bottom of the flask leaving the colloidal supernatant at the top. The precipitated CdO nanoparticles obtained were purified by repeated centrifugation at 14,000 rpm for 5 minutes followed by redispersion of the pellet in deionized water. The biotransformation and stability assessment of ions to nanoparticles was occasionally monitored by means of UV-Vis spectrophotometer and with other characterizing techniques.

2.2. Characterization of CdO Nanoparticles

2.2.1. UV-Vis Absorbance Spectroscopy. The bioreduction of cadmium ions in solution was monitored periodically by measuring the UV-Vis spectrophotometer analysis. UV-visible spectroscopy analysis was carried out by a computer controlled at the wavelength 300–600 nm of UV-vis spectrophotometer (Spekol 1500, Analytik Jena AG) possessing a scanning speed of 300 nm/min and at a resolution of 1 nm. Amount of 0.2 mL of the suspension was diluted in 2 mL of deionized water and measured at room temperature.

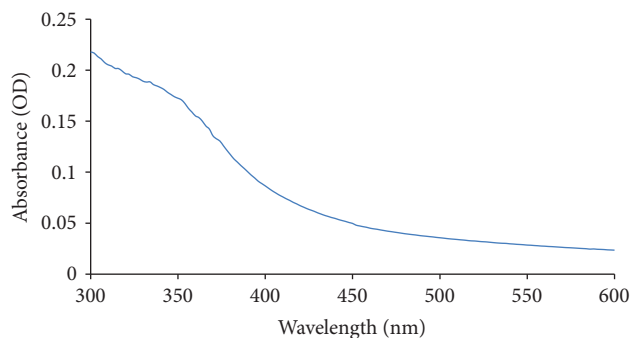


FIGURE 2: UV-Vis absorption spectra for CdO nanoparticles.

2.2.2. Field Emission Scanning Electron Microscope (FESEM). Using FESEM technique, the size, shape, and morphology of the CdO nanoparticles were examined. Dried suspension of gold nanoparticles is synthesized by reduction between cadmium ions, and flower extract of *A. wilhelmsii* plant was used for analysis. The FESEM (Hitachi S-41 FESEM, model XL30) was applied at an accelerating voltage of 25 kV.

2.2.3. Fourier Transforms Infrared Spectroscopy (FTIR). To identify the possible biomolecules responsible for the reduction of the Cd ions and capping of the bioreduced CdO nanoparticles synthesized by the flower broth, FTIR measurements were carried out. After entire reduction of cadmium ions by the flower extract of *A. wilhelmsii* plant, the solution was centrifuged at 10,000 rpm for 15 minutes. The pellet was washed three times with 20 mL of deionized water to get rid of the free proteins/enzymes that are not capping the CdO nanoparticles. For FTIR measurements, the samples were dried at 60°C , and 0.01 g of CdO nanoparticles pellet grinded with 0.1 g of KBr pellets and pressed into a tablet form by pressing the ground mixed material with the aid of a bench press. The resulting pellet was transparent and was used to test the surface functional groups by IR spectroscopy (SHIMADZU FTIR-8300, Japan) where it was scanned between 4000 and $500\ \text{cm}^{-1}$ at a resolution of $4\ \text{cm}^{-1}$ in transmittance mode.

3. Results and Discussion

The reduction of cadmium ions and flower extract lead to the formation of nanoparticles at room temperature. During this reaction, synthesis of cadmium oxide nanoparticles reduced by *A. wilhelmsii* plant made the color of leaf extract change. This change of color was recorded by means of the UV-vis spectrophotometer [27]. Absorption spectra of CdO nanoparticles formed in the reaction media after 30 minutes had an absorbance peak at near 300 nm (Figure 2). The formation of CdO nanoparticles as well as their morphological dimensions by the FESEM study demonstrated that the average size of particles was 35 nm. The shapes were spherical and irregular (Figure 3). The image shows the CdO nanoparticles synthesized by the flower extract of *A. wilhelmsii* plant. FTIR was used to recognize the possible biomolecules responsible for the reduction of the Cd ions and

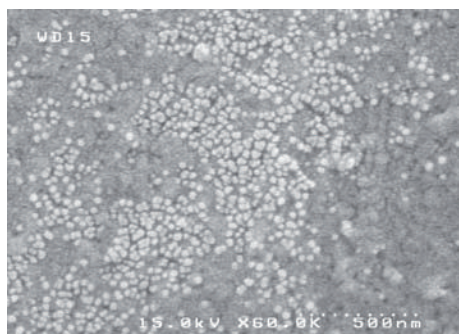


FIGURE 3: FESEM images of CdO nanoparticles at 500 nm scale.

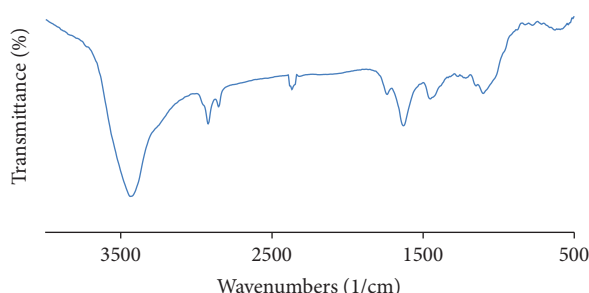


FIGURE 4: FTIR spectra of capped CdO nanoparticles synthesized using the flower extract of *A. wilhelmsii* plant.

capping of the bioreduced CdO nanoparticles synthesized by the flower extract. Figure 4 shows that FTIR peaks at 1103, 1465, 1643, 2360, 2862, 2931, and 3440 cm^{-1} represent the diverse functional groups of the adsorbed biomolecules on the surface of the CdO nanoparticles. The absorption peak at around 1103 cm^{-1} confirmed the binding of $-\text{OCH}_3$ group, peak at 1465 cm^{-1} corresponding to the C-N stretching mode of the aromatic amine group. The peak at 1643 cm^{-1} can be assigned to the amide I band of the proteins and aromatic rings. 2360 cm^{-1} confirmed to the C-C 2862 and 2931 cm^{-1} indicated the secondary amines and C-H stretching vibration modes in the hydrocarbon chains (CH aliphatic). Finally, 3440 cm^{-1} was related to N-H stretching. The variations in the peak positions indicated, presumably, some metabolites such as tannins, flavonoids alkaloids, and carotenoids which are abundant in flower extract and produce the CdO nanoparticles.

4. Conclusions

In this work, biological synthesis of CdO nanoparticles through using flower broth of *A. wilhelmsii* has been exhibited. We characterized these nanoparticles using UV-visible, FTIR, and FESEM. We presume that some components such as tannins, flavonoids, alkaloids, and carotenoids were mainly responsible for the reduction of cadmium ions and the stabilization of the nanoparticles. Advantage of this method is convenient for synthesis of CdO nanoparticles in normal laboratory conditions, in low cost. Biological production of CdO nanoparticles has demonstrated that it is simple,

rapid and green method for producing CdO nanoparticles at room temperature and extracellularly without adding different physical and chemical steps. The reproducibility of nanoparticle biosynthesis with respect to size and shape of produced CdO nanoparticles and time of formation of those is satisfactory. These results show promise for the development of a green process for oxide nanoparticles synthesis. This new method is rapid time scales for biosynthesis of metallic oxide nanoparticles using environmentally benign natural resources as an alternative to chemical synthesis protocols as reductant for synthesizing CdO nanoparticles. In future, it would be important to know the precise mechanism of biosynthesis and to technologically engineer the nanoparticles with the aim of attaining better control over size, shape, and complete monodispersivity.

Acknowledgment

The authors thank the Biology Department of Shiraz University and the Center for Entrepreneurship of Shiraz University for support of this work.

References

- [1] P. Mukherjee, A. Ahmad, D. Mandal et al., "Fungus-mediated synthesis of silver nanoparticles and their immobilization in the mycelial matrix: a novel biological approach to nanoparticle synthesis," *Nano Letters*, vol. 1, no. 10, pp. 515–519, 2001.
- [2] R. Jin, Y. Cao, C. A. Mirkin, K. L. Kelly, G. C. Schatz, and J. G. Zheng, "Photoinduced conversion of silver nanospheres to nanoprisms," *Science*, vol. 294, no. 5548, pp. 1901–1903, 2001.
- [3] G. C. Schatz, A. A. Lazarides, K. L. Kelly, and T. R. Jensen, "Optical properties of metal nanoparticles and nanoparticle aggregates important in biosensors," *Journal of Molecular Structure*, vol. 529, pp. 59–63, 2000.
- [4] N. A. Melosh, A. Boukai, F. Diana et al., "Ultrahigh-density nanowire lattices and circuits," *Science*, vol. 300, no. 5616, pp. 112–115, 2003.
- [5] D. H. Gracias, J. Tien, T. L. Breen, C. Hsu, and G. M. Whitesides, "Forming electrical networks in three dimensions by self-assembly," *Science*, vol. 289, no. 5482, pp. 1170–1172, 2000.
- [6] E. Mayes, A. Bewick, D. Gleeson et al., "Biologically derived nanomagnets in self-organized patterned media," *IEEE Transactions on Magnetics*, vol. 39, no. 2, pp. 624–627, 2003.
- [7] J. Wang, "Nanoparticle-based electrochemical DNA detection," *Analytica Chimica Acta*, vol. 500, no. 1-2, pp. 247–257, 2003.
- [8] M. Han, X. Gao, J. Z. Su, and S. Nie, "Quantum-dot-tagged microbeads for multiplexed optical coding of biomolecules," *Nature Biotechnology*, vol. 19, pp. 631–635, 2005.
- [9] Y. C. Kim, N. C. Park, J. S. Shin, S. R. Lee, Y. J. Lee, and D. J. Moon, "Partial oxidation of ethylene to ethylene oxide over nanosized Ag/ $\alpha\text{-Al}_2\text{O}_3$ catalysts," *Catalysis Today*, vol. 87, no. 10, pp. 153–162, 2003.
- [10] N. L. Rosi and C. A. Mirkin, "Nanostructures in biodiagnostics," *Chemical Reviews*, vol. 104, no. 4, pp. 1547–1562, 2005.
- [11] J. A. Rojas-Chapana and M. Giersig, "Multi-walled carbon nanotubes and metallic nanoparticles and their application in biomedicine," *Journal of Nanoscience and Nanotechnology*, vol. 6, no. 2, pp. 316–321, 2006.

- [12] J. L. Li, L. Wang, X. Y. Liu et al., "In vitro cancer cell imaging and therapy using transferrin-conjugated gold nanoparticles," *Cancer Letters*, vol. 274, no. 2, pp. 319–326, 2009.
- [13] A. Ahmad, P. Mukherjee, S. Senapati et al., "Extracellular biosynthesis of silver nanoparticles using the fungus *Fusarium oxysporum*," *Colloids and Surfaces B*, vol. 28, no. 4, pp. 313–318, 2003.
- [14] K. N. Thakkar, S. S. Mhatre, and R. Y. Parikh, "Biological synthesis of metallic nanoparticles," *Nanomedicine*, vol. 6, no. 2, pp. 257–262, 2010.
- [15] A. R. Binupriya, M. Sathishkumar, K. Vijayaraghavan, and S. I. Yun, "Bioreduction of trivalent aurum to nano-crystalline gold particles by active and inactive cells and cell-free extract of *Aspergillus oryzae* var. *viridis*," *Journal of Hazardous Materials*, vol. 177, no. 1–3, pp. 539–545, 2010.
- [16] J. Karimi Andeani, S. H. Kazemi, S. Mohsenzadeh, and A. Safavi, "Biosynthesis of gold nanoparticles using dried flowers extract of *Achillea wilhelmsii* plant," *Digest Journal of Nanomaterials and Biostructures*, vol. 6, no. 3, pp. 1011–1017, 2011.
- [17] P. Mohanpuria, N. K. Rana, and S. K. Yadav, "Biosynthesis of nanoparticles: technological concepts and future applications," *Journal of Nanoparticle Research*, vol. 10, no. 3, pp. 507–517, 2008.
- [18] J. K. Andeani, H. Kazemi, S. Mohsenzadeh, and A. Safavi, "Biosynthesis of gold nanoparticles using dried flowers extract of *Achillea wilhelmsii* plant," *Digest Journal of Nanomaterials and Biostructures*, vol. 6, no. 3, pp. 1011–1017, 2011.
- [19] K. Manickathai, S. Kasi Viswanathan, and M. Alagar, "Synthesis and characterization of CdO and CdS nanoparticles," *Indian Journal of Pure and Applied Physics*, vol. 46, no. 8, pp. 561–564, 2008.
- [20] J. Y. Park, Y. J. Lee, K. W. Jun, J. O. Aeg, and D. J. Yim, "Chemical synthesis and characterization of highly oil dispersed MgO nanoparticles," *Journal of Industrial and Engineering Chemistry*, vol. 12, no. 6, pp. 882–887, 2006.
- [21] K. M. Abd El-Salaam and E. A. Hassan, "Active surface centres in a heterogeneous CdO catalyst for ethanol decomposition," *Surface Technology*, vol. 16, no. 2, pp. 121–128, 1982.
- [22] D. G. Shchukin, D. V. Sviridov, and A. I. Kulak, "Integrating photoelectrochemical semiconductor sensor for sulphide ion determination," *Sensors and Actuators B*, vol. 76, no. 1-3, pp. 556–559, 2001.
- [23] R. S. Mane, H. M. Pathan, C. D. Lokhande, and S. H. Han, "An effective use of nanocrystalline CdO thin films in dye-sensitized solar cells," *Solar Energy*, vol. 80, no. 2, pp. 185–190, 2006.
- [24] W. Dong and C. Zhu, "Optical properties of surface-modified CdO nanoparticles," *Optical Materials*, vol. 22, no. 3, pp. 227–233, 2003.
- [25] C. H. Bhosale, A. V. Kambale, and A. V. Kokate, "Structural, optical and electrical properties of chemically sprayed CdO thin films," *Solid-State Materials for Advanced Technology*, vol. 122, no. 1, pp. 67–71, 2005.
- [26] M. Ghosh and C. N. R. Rao, "Solvothermal synthesis of CdO and CuO nanocrystals," *Chemical Physics Letters*, vol. 393, no. 4–6, pp. 493–497, 2004.
- [27] S. Reddy, B. E. Kumara Swamy, U. Chandra, B. S. Sherigara, and H. Jayadevappa, "Synthesis of CdO nanoparticles and their modified carbon paste electrode for determination of dopamine and ascorbic acid by using cyclic voltammetry technique," *International Journal of Electrochemical Science*, vol. 5, no. 1, pp. 10–17, 2010.

