Iranian Journal of Analytical Chemistry
Volume 9, Issue 2, September 2022 (**-**) Original Research Article
مجله ایرانی شیمی تجزیه
دوره ۹، شماره ۲، مهر ۱۴۰۱ (**-**)

Green Synthesis of Silver Nanoparticles Using Sugar Beet Leaf Extracts and Its Antibacterial Activity

Shahryar Pashaei*[1], Samaneh Safari[1], Soleyman Hosseinzadeh[2]
1. Department of Chemistry, Payame Noor University, Tehran, Iran
2. Department of Engineering, Payame Noor University, Tehran, Iran
Received: 9 May 2022 **Accepted:** 4 July 2022
DOI: 10.30473/ijac.2022.63956.1237

Abstract
In the present study, synthesis of silver nanoparticles and its antibacterial activity were investigated. Silver nanoparticles were rapidly synthesized using leaf extract of beet sugar leaf the formation of nanoparticles was observed within 1 hr. The results recorded from UV–vis spectrum, Transmission electron microscopy (TEM) and X-ray diffraction (XRD) support the biosynthesis and characterization of silver nanoparticles. The UV-Visible spectrophotometer was indicated absorbance peak in range of 435-440 nm. From high resolution transmission electron microscopy (HRTEM) analysis, the size of the silver nanoparticles was measured 35–40nm. Further, the antibacterial activity of synthesized silver nanoparticles showed effective inhibitory. It showed that antibacterial activity increased by addition concentration of silver nano particle. The 0.008 molar concentrations of AgNPs, antibacterial activity was higher than other concentrations. Results confirmed this protocol as simple, rapid, one step, and eco-friendly, nontoxic and alternative conventional physical/chemical methods. Nanoparticle synthesis is a novel research are to search for an eco-friendly manner and green materials for potential applications in the fields of medicine and drug delivery.

Keywords
Beet Sugar Leaf; Green Synthesis; Silver Nanoparticles; Bactericidal Activity; Quercetin.

1. INTRODUCTION

The ‘green’environment friendly processes in chemistry and chemical technologies are becoming increasingly popular and are much needed as a result of worldwide problems associated with environmental concerns [1]. Green chemical engineering is a way to not only improve the environment but positively environment but positively impact the client's bottom impact the client's bottom line. Avoiding the generation of waste (including energy) or pollutants can often be more cost pollutants can often be more cost-effective than controlling or effective than controlling or disposing of pollutants once formed. Greener syntheses of nanoparticles also provide advancement over other methods as they are simple, one step, cost-effective, environment friendly and relatively reproducible and often results in more stable materials [2]. In the past decade, several research groups have developed metal oxide nanoparticles using savvy routes. Among them, a significant category of silver nanoparticles (AgNPs) have gained importance since few years. There has been much recent interest in using silver nanoparticles (AgNPs) in new technologies owing to their drastically enhanced properties over bulk silver, especially particles of diameters 30 nm and smaller [3]. These NPs are increasingly being incorporated into consumer products despite rising evidence suggesting AgNPs have toxic effects on humans and experimental animal models meant to mimichuman bio- and neurochemistry such as mice, rats, and Drosophila. [4]. There are techniques for the syntheses of silver nanoparticles like ion sputtering, chemical reduction, sol gel, etc [5]. The techniques for obtaining nanoparticles usingnaturally occurring reagents such as sugars, biodegradablepolymers (chitosan, etc.), plant extracts, and microorganismsas reductants and capping agents could be consideredattractive for nanotechnology. Microorganisms canalso be utilized to produce nanoparticles but the rate of syntheses is slow compared to routes involving plants mediatedsynthesis [6].The preparation of AgNPs using plant-based extractsiswidely growing in popularity; recently proposed syntheses usereagents such as many types of leaf extract,[7−13] includingmenthol,[14]aloe vera,[15]clove extract,[16]edible mushroomextract,[17]and extracts from coffees and teas[18].AgNP synthesisusing the extract of the navel orange (Citrus sinensis) wasproposed by Kaviya[19].AgNPs were both reducedfrom silver nitrate ($AgNO_3$) and capped by the compoundspresent in the orange peel extract.The objective of the work here was to use $AgNO_3$ and aqueous extracts of sugar beet leaf to prepare

*Corresponding Author: shahryarpashaei@pnu.ac.ir

AgNPs in a phymidatation synthesis. The nontoxic environmentally friendly synthesis proposed here produced AgNPs of an appropriately small size distribution using the sugar beet leaf extracts.

2. EXPERIMENTAL

Typically, a plant extract-mediated bio reduction involvesmixing the aqueous extract with an aqueous solution of theappropriatemetal salt. The synthesis of nanoparticle occurs atroom temperature and completes within a few minutes.

2.1. Preparation of plant extract

Sugar beet leaf extract was used to prepare silver nanoparticles on the basis of cost effectiveness, ease of availability and its medicinal property. Fresh leaves were collected from sugar beet farmer in naghadeh city of iran. They were surface cleaned with running tap water to remove debris, followed by double distilled water and air dried at room temperatureand then further cut into small pieces to make powder by haven. About 10 gr of finely powder sugar beet leaf were kept in a beaker containing 100 mL double distilled water a during one day and then boiled for 2 hrs. The extract was cooled down and filtered with Whatman filter paper and extract was stored at 4 °C. Finally, the extract was used for the synthesis of silver nanoparticles.

2.2. Preparation of silver nanoparticles

Solutions of silver nitrate were prepared at different concentration of $AgNO_3$in an Erlenmeyer flask. Then, 5 mL of plant extract was added separately to 20 mL of silver nitrate solution and incubated in a dark chamber to minimize photo-activation of silver nitrate at 45 °C.Silver nanoparticles have been synthesized by varying concentration of $AgNO_3$ (1 mM,4mM, 8mMand 10 mM).Reduction of Ag^+ to Ag° was confirmed by the colour change of solution from yellow to dark. Its formation was confirmed by using UV-Visible spectroscopy. Acetone was added to aqueous samples in a ratio of 1:2 to encourage precipitation of AgNPs. After allowing the AgNPs to precipitate, the samples were centrifuged for 10 min at 4500 rpm. Then, it dried at 60°C for 3 hr for further characterization. For antimicrobial applications, the AgNPs were redispersed in D.I water without drying.The chemical structures of the compounds from alcoholic leaves extract of sugar beet have been indicated in Fig. 1 [20].

2.3. Characterization of synthesized silver nanoparticles

2.3.1. UV−Visible Spectroscopy

UV−vis spectra were collected in an optical-quality quartz cuvette with a 1 cm path length, requiring approximately 2 mL of solution to fill past the light path of the instrument (Agilent 8453 system, Santa Clara, CA). Spectra were collected at room temperature using the appropriate aqueous sugar beet leaf extracts as the blank, always taken with the same cuvette as used for analysis. Solutions were diluted immediately before analysis, if required, in order to normalize absorbance to approximately 2 AU.Spectra were collected from 300 to 700 nm.

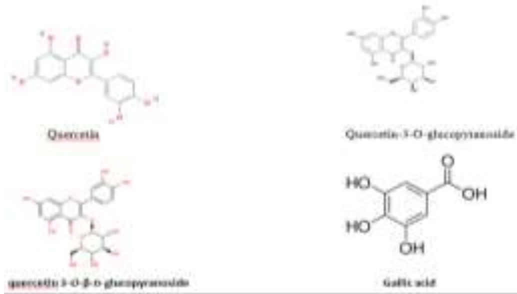


Fig. 1. Chemical structure of the compounds fromalcoholic leaves extract of sugar beet [20]

2.3.2. Powder X-ray Diffraction

X-ray diffraction was performed on a Scintag X-2 advanced diffraction system (Cupertino, CA) equipped with Cu Kαradiation (λ= 1.54 Å) using a drop-cast sample of the AgNPs on a zero background Si plate sample holder (30 mm×30 mm×2.5 mm SiO_2 single crystal plate; MTI Corporation, Richmond, CA).AgNP samples were concentrated via centrifugation as described aboveprior to being drop-casted.

2.3.3. Transmission Electron Microscopy (TEM)

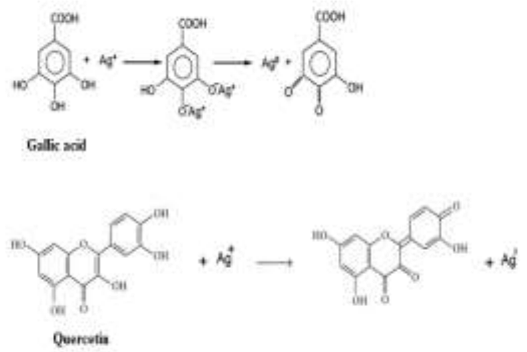
Transmission electron microscopy (TEM) analysis of the sample was done using PHILIPS- CM 200 instrument operated at an accelerating voltage of 200 kV with resolution of 0.23 nm. A drop of the solution was placed on carbon coated copper grid and later exposed to infrared light (45 minutes) for solvent evaporation.

3. RESULT AND DISCUSSION

3.1. UV-vis absorption spectroscopy analysis

In addition of sugar beet leaf extracts intothe beaker containing aqueous solutionof silver nitrate led tothe change in the colour of the solution to a dark brown (shown inFig. 2). The dark brown color showed the formation ofsilver nanoparticles. Reduction of the Ag^+ions wasmonitored with respect to time using UV-visiblespectral analysis [21]. The aqueous sugar beet leaf extractsinvolves main metabolitesalong with gallic acid, alkaloids,quercetin, quercetin 3-*O*-β-D-glucopyranoside,tannins, phytosterols,etc [22]. The flavonoids are strong reducing agentsand are contributed to the reduction of Ag^+ions tonanoparticles. However, flavonoids are powerful reducingagents and they may also directly scavenge molecularspecies of active oxygen, this antioxidant activity offlavonoids emanates from their ability to donate electrons or hydrogen atoms. The reasonable mechanism ofAgNPs formation may be suggested as the flavonoidsare oxidized during the reduction of Ag^{+}toAgNPs.Chemistry behind the nanoparticles formation issignified in Equation 1, which states that flavonoidsare responsible for the reduction of Ag^{+}ions andAgNPs are stabilized through negatively chargedcarboxylate groups of proteins. Therefore, reductionand capping processes by the biomolecules present inthe leaf extract could be accountable for the lengthystability.

Fig. 2. Digital optical images of (a), $AgNO_3$ (10 mM), (b) leaf beet sugar extracted and (c) nanosilver solution



Equation. 1. Indicate the possible silver nanoparticles formation mechanism in the leaf sugar beet extract.

The characteristic absorption peak at 435nm in UV–visspectrum (Fig. 3) confirmed the formation of silver nanoparticles. Surface Plasmon Resonance (SPR) patterns, characteristics of metal nanoparticles strongly depend onparticle size, stabilizing molecules or the surface adsorbed particles and the dielectric constant of the medium. The single SPRbandin the early stages of synthesis corresponds to the absorption spectra of spherical nanoparticles. Many SPR bands resulted later, withincrease in the incubation period and two such bands were prominent with 4h incubation, it indicates the formation of anisotropicmolecules that later stabilized in the medium.In all experiments, by adding sugar beet leaf extract intothe beakers containing aqueous solutionof silver nitrate led tothe change in the colour of the solution to yellow to dark (shown inFig. 3) within reaction duration due to excitation of surface Plasmon vibrations in silver nanoparticles [23]. The appearanceof the brown colour was due to the excitation of the SurfacePlasmon Resonance (SPR), typical of silver nanoparticleshaving absorbance values which were reported earlier in thevisible range of 435-440 nm [24].The UV-vis spectrarecorded, implied that most rapidbio reductionwas achievedusing sugar beet leaf extract as reducing agent. The UV-visspectra and visual observation revealed that formation ofsilver nanoparticles occurred rapidly within 30 min.As shownin Fig. 3, the synthesized AgNPs exhibited a broadabsorbance at λ_{max}= 435 nm for AgNPs by sugar beet extract,owing to the surface plasmon resonance of the AgNPs [25]. ThisPlasmon resonance is an intrinsic property of AgNPs andarises from the coupling between the electron clouds on theAgNP surface with the incident electromagnetic radiation [26-29]and typically occurs between 380 to 420 nm depending on thesize of the AgNPs analyzed.

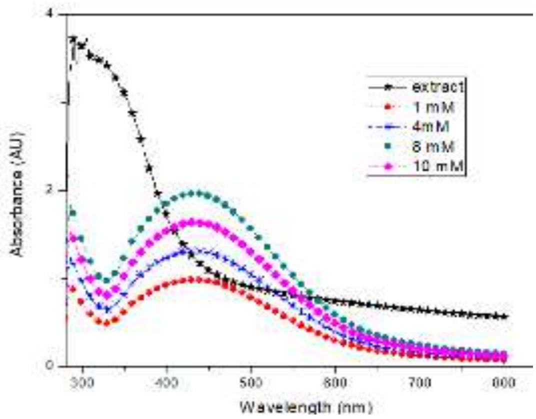


Fig. 3. UV−vis absorbance spectrum of synthesized AgNPs from 250−800 nm is shown, with the absorbance maximum occurring at λ_{max}=435 nm for AgNPsfabricated with different concentrations of $AgNO_3$ keeping fixed the volume of sugar beet extract and λ_{max}= 310 nm (leaf sugar beet extract).

3.2. X-ray diffraction analysis (XRD)

The crystalline nature of AgNPs was confirmed from XRD analysis. The nature of AgNPswas identified to be crystalline using XRD analysis with Cu Kα target at 20–80 °C. The XRD pattern of the silver nanoparticles is shown in Fig. 4. The average grain size of the silver nanoparticles formed in the bio reduction process was determined using Scherr's formula, $d=(0.9\lambda\times180^{\circ})/\beta \cos(\Theta)\,\pi$ and was estimated as 4nm

(Fig. 4).The peaks assigned to the diffraction pattern clearly indicate peaks corresponding to face-centered cubic (FCC) silver, with peaks at 2θ= 38.4°,44.6°, 64.4°, 77.3°, and 81.7° corresponding to the (111),(200), (220), (311), and (222) planes, respectively. The broadness of the peakswasindicated the small size of the AgNPs synthesized. The interplanarspacing (d_{hkl}) values (2.349, 2.040, 1.437, 1.239, and 1.176 Å) was obtained from the XRD spectrum of silver nanoparticles. It was in agreement with the standard silver values[30].

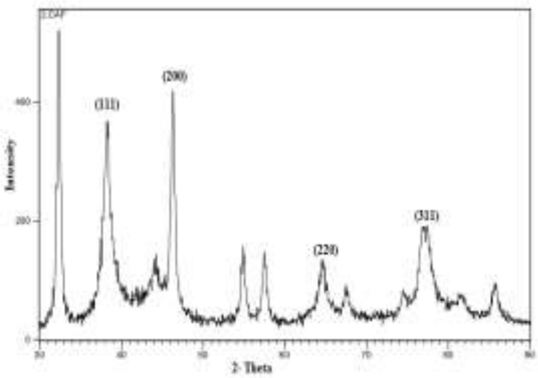


Fig. 4. XRD pattern of synthesized AgNPs by sugar beet extracts.

3.3. TEM Analysis

Transmission electron microscopy (TEM) is used todetermine particle size, shape and morphology of nanoparticles. It showed that the silver nanoparticles are well dispersed and predominantly spherical nature in shape, while some of theNPs have beenfound to be having structures of irregular shape as shown inFig. 5. The TEM image of a single nanoparticle is reveled crystalline nature of the particles. The nanoparticles are homogeneous and spherical.It conformed to the shape of SPR band in the UV-visiblespectrum. From Fig. 4, it was obtained that average particle size about 15 nm. In spite of, some of the silver nanoparticles were cluster and irregular shape.

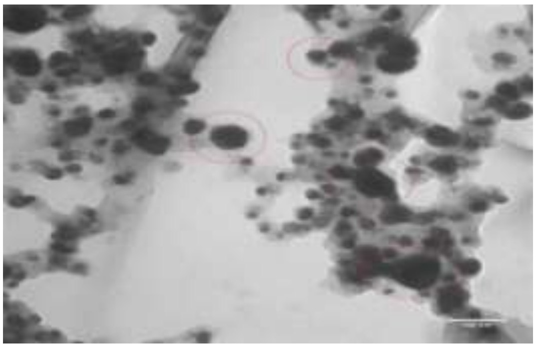


Fig. 4.TEM image of synthesized silver nanoparticles.

3.4. Antimicrobial activity

Silver nanoparticles most widely have been usedin the health industry, medicine,textile coatings, food storage, dye reduction, wound dressing,antiseptic creams and a number of environmental applications, because of their antimicrobial properties [31].We haveexamined sugar beet extract mediated silver nanoparticles aspossible antibacterial agents. The plant extract and thosemediated silver nanoparticles were immediately tested forrespective antimicrobial activities towards both gram positive(S. aureus) and gram negative (E. coli) bacterial strains showingthe zones of inhibition.The results of antibacterial activities of prepared silvernanoparticles evaluated from the disc diffusion method aregiven in Fig.5. The silver nanoparticles showed efficientantimicrobial property compared to other due to theirextremely large surface area providing better contact with cellwall of microorganisms [32].Fig. 5 has been indicated that silver nanoparticle has shown antibacterial activity against all tested microorganism and maximum Zoneof inhibition was found against Bascillus cereus. It showed that antibacterial activity increased by addition concentration of silver nano particle. The 0.008 molar concentrations of AgNPs, antibacterial activity was higher than other concentrations (Fig. 5). Biological molecules extracted from living systems show potential role and have become preferred choice in the synthesis of AgNPs, which are summarized in Table 1.

Fig. 5. Antibacterial activity of silver nanoparticles synthesized using the leaf extract of sugar beet against E. coli.

Table 1. Plant- mediated synthesis of AgNPs, and the phytochemicala involved in reduction Ag^{+} ions.

Reducing agents		Phytochemicals involved	AgNPs characteristics (shape and size)	Reference
Plant name	Plant parts used			
Musa	Flower	proteins	Spherical;12.6-15.7 nm	33
Prosopis Juliflora	Leaf	Alcoholic,Phenolic, Aromatic Compound	Spherical;10-20 nm	34
Withania coagulans	Leaf	Amides, flavonoides, phenols, amino acids	Spherical;14 nm	35
Solanum	Leaf	Phenolic compound	Spherical; 35-50 nm	36
Piper longum L.	Leaf	Hydroxyl, carbonyl, amide, flavonoids, terpenoids,	Spherical; 25-32 nm	37
Aesculus	Leaf	Saponin, protein, alkanes, ester	Spherical; 50 nm	38
Ocimum Sanctum	Leaf	Quercetin	Spherical; 11.35-14.6 nm	39
Oriza sativa	Leaf	Sugars,Proteins, phenolics	Spherical;3.7-29 nm	40
Sugar beet leaf	Leaf	Quercetin, flavonoids, polyphenoles, Hyderoxyl, carboxyl	Spherical;15 nm	Present work

4. CONCLUSION

The present study demonstrates the use of unreported sugar beet extracts for the quick synthesis of silver nanoparticles from silvernitrate. Variation in reaction conditions affected nanoparticlesynthesiswhere the reactionmixtures displayed typical colorsand UV–visible spectra, characteristic of silver nanoparticles. The biosynthesized nanoparticles produced by this novel, cost-effective, non-toxic, environmentally safe protocol were characterized by a variety of standard analytical techniqueuselike XRD,TEM and were further tested against bacterial. Nanoparticle synthesis is a novel research are to search for an eco-friendly manner and green materialsfor potential applications in the fields of medicine and drug delivery.

Acknowledgments

The authors gratefully thank Mr.SheirpoorHead of the laboratory ofPayamenooruniversity of iranfor giving permission to characterizenanoparticles in their respective departments.

REFERENCES

[1] P. Thuesombat, S. Hannongbua, S. Akasit, and S. Chadchawan, Ecotoxicology and environmental safety effect of silver nanoparticles on rice (Oryza sativa L. cv. KDML 105) seed germination and seedling growth. Ecotoxicology and Environmental Safety, 104, 2014, 302-309.

[2] Mittal, J., Batra, A., Singh, A., & Sharma, M. M. (2014). Phytofabrication of nanoparticles through plant as nanofactories.Advances in Natural Sciences: Nanoscience and Nanotechnology, 5. http://dx.doi.org/10.1088/2043-6262/5/4/043002, 043002.

[3] Auffan, M.; Rose, J.; Bottero, J.-Y.; Lowry, G. V.; Jolivet, J.-P.; Wiesner, M. R. Towards a definition of inorganic nanoparticles from an environmental, health and safety perspective. Nat. Nanotechnol.2009,4, 634−641.

[4] Suresh, A. K.; Pelletier, D. A.; Wang, W.; Morrell-Falvey, J. L.;Gu, B.; Doklycz, M. J. Cytotoxicity induced by engineered silver nanocrystallites is dependent on surface coatings and cell types. Langmuir2012, 28, 2727−2735,

[5] Bindhu, M. R., &Umadevi, M. (2015). Antibacterial and catalytic activities of green synthesized silver nanoparticles. SpectrochimicaActa Part A: Molecular and Biomolecular Spectroscopy, 135, 373-378.

[6] Ahmed, S., Ikram, S. Chitosan and its derivatives: a review in recent innovations. International Journal of Pharmaceutical Sciences and Research. 2015, 6(1), 14- 30.

[7] Hebbalalu, D.; Lalley, J.; Nadagouda, M. N.; Varma, R. S.Greener techniques for the synthesis of silver nanoparticles using plant extracts, enzymes, bacteria, biodegradable polymers, and microwaves.ACS Sustainable Chem. Eng.2013, 1(7), 703−712, DOI: 10.1021/sc4000362.

[8] Kouvaris, P.; Delimitis, A.; Zaspalis, V.; Papadoupoulous, D.; Tsipas, S. A.;

Michailidis, N. Green synthesis and characterization of silver nanoparticles produced usingArbutusUnedoleaf extract. Mater. Lett.2012, 76,18−20.
[9] Kaviya, S.; Santhanalakshmi, J.; Viswanathan, B. Green synthesis of silver nanoparticles usingPolyalthialongifolialeaf extract along with D-sorbitol: Study of antibacterial activity.J. Nanotechnol. 2011, 2011, DOI:10.1155/2011/152970.
[10] Jha, A. K.; Prasad, K.; Kumar, V.; Prasad, K. Biosynthesis of silver nanoparticles using Eclipta leaf. Biotechnol. Prog. 2009, 25, 1476−1479.
[11] Jha, A. K.; Prasad, K.; Prasad, K.; Kulkarni, A. R. Plant system: nature’s nanofactory.Colloids Surf., B2009, 73, 219−223.
[12] Huang, J.; Li, Q.; Sun, D.; Lu, Y.; Su, Y.; Yang, X.; Wang, H.; Wang, Y.; Shao, W.; He, N.; Hong, J.; Chen, C. Biosynthesis of silver and gold nanoparticles by novel sundriedCinnamomum camphoraleaf.Nanotechnol.2007, 18, DOI:10.1088/0957-4484/18/10/105104.
[13] Leela, A.; Vivekanandan, M. Tapping the unexploited plant resources for the synthesis of silver nanoparticles.African J. Biotechnol.2008, 7, 3162−3165.
[14] Mubarak Ali, D.; Thajuddin, N.; Jeganathan, K.; Gunasekaran, M. Plant extract mediated synthesis of silver and gold nanoparticles and its antibacterial activity against clinically isolated pathogens. Colloids Surf., B2011, 85, 360−365.
[15] Chandran, S. P.; Chaudhary, M.; Pasricha, R.; Ahmad, A.; Sastry, M. Synthesis of gold nanotriangles and silver nanoparticles using Aloe vera plant extract.Biotechnol. Prog.2006, 22, 577−583.
[16] Vijayaraghavan, K.; Kamala Nalini, S. P.; UdayaPrakash, N.; Madhankumar, D. Biomimetic synthesis of silver nanoparticles by aqueous extract ofSyzygiumaromaticum. Mater. Lett.2012, 75,33−35.
[17] Philip, D. Biosynthesis of Au, Ag, and Au-Ag nanoparticles using edible mushroom extract.Spectrochim. Acta, Part A2009, 73, 374−381.
[18] Nadagouda, M. N.; Varma, R. S. Green synthesis of silver and palladium nanoparticles at room temperature using coffee and tea extract.Green Chem.2008, 10, 859−862.
[19] Kaviya, S.; Santhanalakshmi, J.; Viswanathan, B.; Muthumary, J.; Srinivasan, K. Biosynthesis of silver nanoparticles usingCitrussinensis peel extract and its antibacterial activity. Spectrochim. Acta, Part A 2011, 79, 594−598.
[20] Souad E. El-Gengaihi, Manal A Hamed, Doha H. Aboubaker, Abdel-Tawab H. Mossa. Int J Pharm PharmSci, 8(4), 281-286,2016.
[21] G.A. Bhaduri, R. Little, R.B. Khomane, S.U. Lokhande, B.D. Kulkarni, B.G. Mendis, et al., Green synthesis of silver nanoparticles using sunlight, J. Photochem. Photobiol. A Chem.258 (2013) 1-9.
[22] H. Joy Prabu, I. Johnson, Plant-mediated biosynthesis and characterization of silver nanoparticles by leaf extracts ofTragiainvolucrata, Cymbopogon citronella, Karbala International Journal of Modern Science 1, 5 (2015) 237-246.
[23] Veerasamy, R., Xin, T. Z., Gunasagaran, S., Xiang, T. F. W., Yang, E.F.C., Jeyaumar, N., journal of Saudi Chemical Society, 15, 2011, 113-120.
[24] Banerjee, P., Satapathy, M., Mukhopahayay, A., leaf extract mediated green synthesis of silver nanoparticles from widely available indian plants: synthesis, characterization, antimicrobial property and toxicity analysis.Das, 2014).
[25] Kim, T.-G.; Kim, Y. W.; Kim, J. S.; Park, B. Silver-nanoparticledispersion from the consolidation of Ag-attached silica colloid. J.Mater. Res.2004, 19, 1400−1407.
[26] Bohren, C. F.; Huffman, D. R.Absorption and Scattering of Lightby Small Particles; Wiley: New York, 1983.
[27] Link, S.; El-Sayed, M. A. Optical properties and ultrafastdynamics of metallic nanocrystals.Annu. Rev. Phys. Chem.2003, 54,331−366.
[28] 28. Kreibig, U.; Vollmer, M. Optical Properties of Metal Clusters;Springer-Verlag: New York, 1995.
[29] Kerker, M. The optics of colloidal silver: Something old andsomethingnew.J. Colloid Interface Sci. 1985, 105, 297−314.
[30] G. Singhal, R. Bhavesh, K. Kasariya, A.R. Sharma, R.P. Singh, Biosynthesis of silver nanoparticles using Ocimum sanctum (Tulsi) leaf extract and screening its antimicrobial activity, J. Nanoparticle Res. 13 (2011)2981–2988.
[31] Gao, X., Yourick, J. J., Topping, V. D., Black, T., Olejnik, N.,Keltner, Z., et al. Toxicogenomic study in rat thymus ofF1 generation offspring following maternal exposure to silverion. Toxicology Reports. (2014).
[32] Ibrahim, H. M. M. Green synthesis and characterization ofsilver nanoparticles using banana peel extract and theirantimicrobial activity against representative

microorganisms.Journal of Radiation Research and Applied Sciences. 2015.

[33] S. Valsalam , P. Agastian , M. Valan Arasu , N. Abdullah Al-Dhabi , A.K. Mohammed Ghilan , K. Kaviyarasu , B. Ravindran , S. Woong Chang , S. Arokiyaraj, Biosynthesis of silver and gold nanoparticles using Musa acuminate colla flower and its pharmaceutical activity against bacteria and anticancer efficacy, Journal of Photochemistry and Photobiology B:Biology. 201(2019) 111-670.

[34] G. Arya , R. M. Kumari , N. Gupta , A. Kumar , R. Chandra, S. Nimesh, Green synthesis of silver nanoparticles using Prosopis juliflora bark extract:reaction optimization, antimicrobial and catalytic activities, Artif. Cells, nanomed Biotechnol. 46(5) (2018) 985-993.

[35] A. Asghar, M. N. Aamir, F. A. Sheikh, N. Ahmad, N. F. Alotaibi, S. Nasir A. Bukhari, Preparation,Characterization of Pregabalin and *Withania coagulans* Extract-Loaded Topical Geland Their Comparative Effect on Burn Injury, Gels, 402 (2022) 1-18.

[36] A. Moreira-Muñoz and M. Muñoz-Schick, Rediscovery and taxonomic placement of *Solanum polyphyllum* Phil. (Solanaceae), a narrow endemic from the Chilean Atacama Desert, PhytoKeys 156 (2020) 47–54 .

[37] N. Jamila , N. Khan , A. Bibi , A. Haider , S. Noor Khan, A. Atlas and U. Nishan, Piper longum catkin extract mediated synthesis of Ag, Cu, and Ni nanoparticles and their applications as biological and environmental remediation agents , Arabian Journal of Chemistry, 13 (2020) 6425–6436.

[38] F. Öztürk Küp, S. Çoşkunçay and F. Duman, Biosynthesis of silver nanoparticles using leaf extract of *Aesculus hippocastanum* (horse chestnut): Evaluation of their antibacterial, antioxidant and drug release system activities, Materials Sci. and Engineering:C. 107 (2020) 110207.

[39] A. Chaudhary1, S. Sharma1, A. Mittal1, S. Gupta1, and A. Dua, Phytochemical and antioxidant profiling of *Ocimum sanctum*, J Food Sci Technol, 57(10) (2020) 3852–3863.

[40] J. G. Kim, B.-C. Park, C. Liu, G. Qiang, H. J. Kim and E. K. Ahn, Productivity and quality of whole crop rice varieties in relation to plant components, Grassland Science, 66 (2020) 40-47.

سنتز سبز نانوذرات نقره با استفاده از عصاره برگ چغندرقند و فعالیت ضد باکتریایی آن

شهریار پاشایی*[۱]، سمانه صفری[۱]، سلیمان حسین زاده[۲]

۱. گروه شیمی، دانشگاه پیام نور، تهران، ایران

۲. گروه مهندسی شیمی، دانشگاه پیام نور، تهران، ایران

تاریخ دریافت: ۱۹ اردیبهشت ۱۴۰۱ تاریخ پذیرش: ۱۳ تیر ۱۴۰۱

چکیده

در مطالعه حاضر، سنتز نانوذرات نقره و فعالیت ضد باکتریایی آن مورد بررسی قرار گرفت. نانو ذرات نقره با استفاده از عصاره برگ چغندر به سرعت سنتز و نانوذرات نقره در عرض ۱ ساعت تشکیل شد. نتایج ثبت شده از طیف سنجی UV-Vis، میکروسکوپ الکترون عبوری (TEM) وپراش پرتو ایکس (XRD) خصوصیات نانو ذرات نقره را تعیین می کنند. طیف سنجی UV-Vis پیک جذب نانو ذرات نقره را در محدوده ۴۳۵ – ۴۴۰ نانومتر نشان می دهد. از تجزیه و تحلیل میکروسکوپ الکترون عبوری با وضوح بالا (HRTEM) اندازه نانوذرات نقره را ۳۵ تا ۴۰ نانومتر اندازه‌گیری شد. علاوه بر این، فعالیت ضد باکتریایی نانو ذرات نقره با افزایش غلظت نانو افزایش می یابد و اثر موثری داشت. غلظت ۰/۰۰۸ مولی نانوذرات نقره، فعالیت ضدباکتریایی بیشتری نسبت به سایر غلظت‌ها داشت. نتایج این پروتکل را به عنوان روش‌های فیزیکی/شیمیایی معمولی، ساده، سریع، یک مرحله‌ای و سازگار با محیط زیست و غیرسمی تأیید نمود. سنتز نانوذرات به روش سنتز سبز، یک تحقیق جدید برای جستجوی روشی سازگار با محیط زیست و مواد سبز و برای کاربردهای بالقوه در زمینه های پزشکی و دارورسانی می باشد.

واژه‌های کلیدی

برگ چغندر قند ؛ بیوسنتز؛ نانو ذرات نقره؛ فعالیت باکتریایی؛ کوئرستین.