DOI: http://dx.doi.org/10.32571/ijct.1341868 E-ISSN: 2602-277X

International Journal of Chemistry and Technology

http://dergipark.org.tr/ijct

Research Article

Green synthesis and characterisation of silver nanoparticles using *Prunus laurocerasus* L. fruits

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Received: 12 August 2023; Accepted: 20 December 2023

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Citation: Karan and Erenler, N. *Int. J. Chem. Technol.* **2023**, 7 (2), 157-161.

ABSTRACT

Nanotechnology is the most well-known disciplines of science due to its wide range of applications. Nanoparticles have been used commonly for agriculture, electronic, medicine, medicinal material, and sensory. In this study, *Prunus laurocerasus* L. fruits were heated in distilled water for 2 hours at 40°C. After filtration, the treatment of silver nitrate (1.0 mM) with plant solution yielded silver nanoparticles (AgNPsμ@pl). Advanced spectroscopic techniques elucidated the synthesized AgNPs@pl. The functional moieties of secondary metabolites responsible for capping, reducing and stabilizing agents were determined by Fourier transform infrared spectroscopy (FTIR). The surface plasmon resonance at 468 nm was presented by UV-Vis spectroscopy. Transmission electron microscopy (TEM) displayed the particles as spherical in the size of 15 nm. The structure and particle size were also calculated by X-ray diffraction (XRD) spectroscopy and AgNPsμ@pl were found as cubic structure with the particle size of 17 nm. The zeta potential confirmed the stability of nanostructures. The high negative zeta potential value (-16.5 mV) displayed the dispersion of the nanostructure with stability.

Keywords: *Prunus laurocerasus* fruits, nanoparticles, green synthesis, spectroscopy, natural products.

1. INTRODUCTION

Nanotechnology is developing as an important branch of science with various applications such as biomedical, pharmaceutical, catalysis, sensors, cosmetics, agriculture, textiles, electronics, and energy.[1-2] Nanomaterials include particles ranging in size from 1 to 100 nm and their applications. Several chemical and physical protocols have been used for the synthesis of metal nanoparticles.[3-4] These conventional methods are considered as expensive, time-consuming, unsafe and hazardous to the environment as they contain toxic chemicals. Therefore, researchers have turned to the biological route of nanoparticle synthesis from various plant parts, as these procedures are simple, sustainable, eco-friendly and cost-effective.[5] Metal nanoparticles are considered favorable in biomedical applications due to their high surface area to volume ratio. The use of plants as reducing and capping agents in nanoparticle synthesis has developed as a new field of nanoscience.[6] Besides pure compounds, plant extracts are also used for nanoparticle synthesis.[7] Plants consist of secondary metabolites which are the fascinating compounds.[8-12] Nanoparticles are crucial in the discovery and development of new drugs because of their small size, high surface-to-volume ratio, and adaptability for surface alterations.[13] Recent scientific studies show that metallic nanoparticles can be used effectively in the treatment of various diseases, especially cancer.[14] Metallic nanoparticles have been reported to have various biological activities including antibacterial, antiviral, and antifungal. The use of silver nanoparticles (AgNPs) has been reported to be relatively less toxic, environmentally safe and strongly interact with cellular membranes in comparison with the other metallic nanoparticles.[15] Although chemically synthesized AgNPs exhibit significant anticancer activity, they have been reported to be toxic against normal cells. The feasible reason for the cytotoxicity of chemically synthesized silver nanoparticles may be the usage of toxic chemicals in

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synthetic process. Thus, in recent years, researchers have focused on studies that reduce the cytotoxicity of silver nanoparticles.[16-17]

Accordingly, with the rise awareness of a clean environment, green nanotechnological approaches are becoming increasingly important. The medical importance of green synthesized nanoparticles is increasing as they have many excellence such as non-toxicity, environmental friendliness, high stability, low aggregation properties, and high biological activity.[18] Natural products such as bacteria, fungi and plants can be used for the synthesis of nanoparticles. Biological agents exhibit reducing and stabilizing properties in nanoparticle synthesis. Therefore, the use of biological agents contributes to the production of non-toxic, environmentally friendly nanoparticles.[19] Currently, roots, stems, leaves, and flowers of plants are widely preferred for the green synthesis of nanoparticles. Since the natural compounds in each part of the plant are different, the biological activities of the nanoparticles synthesized from corresponding parts differ.[20]

Medicinal plants have been used for food and pharmaceuticals for years, since they contain bioactive compounds revealing the significant biological properties.[21-25] The advancement of spectroscopy in 19th century, plants become the focus of science. Hence, bioactive compounds have been isolated from plants and their structures were elucidated by spectroscopic techniques.[26-34]

Cherry laurel (*Prunus laurocerasus* L.) belongs to the Rosaceae family and is a small tree with evergreen leaves and small cherry fruits. It grows in Asia, the Balkans and Europe. Cherry laurel was reported for treatment of digestive disorders, bronchitis, eczema, and haemorrhoids. Cherry laurel berries contain chlorogenic, vanillic, caffeic and benzoic acids, and the nutritional and pharmaceutical value of these berries derives from the related compounds.[35]

In this study, silver nanoparticles were generated by Cherry laurel, and efficient spectroscopic techniques were used for the characterization of green synthesized silver nanoparticles.

2. MATERIALS and METHODS

2.1. Plant material

Prunus laurocerasus L. fruits were collected from Black Sea region (Rize-Cayeli) in July 2022.

2.2. Synthesis of silver nanoparticles

Prunus laurocerasus L. fruits were dried at shade and then powdered. Afterward, these fruits (5.0 g) were extracted with distilled water (150 mL) at 50 °C for 2 hours. After filtration by Whatman (No 1) the solution was treated with silver nitrate solution (1.0 mM, 150 mL) for 2 hours at room temperature. The mixture was centrifugated for 15 min at 10000 rpm to yield the silver nanoparticles washed throughout with distilled water and dried by lyophilization.[36]

2.3. Characterization

UV-Vis analysis was performed with a UV-2600 spectrophotometer operation in the transmission mode. Transmission electron microscopy (TEM) image was attained by Hitachi HighTech HT7700. Zetasizer Nano ZSP (Malvern) was used for zeta potential measurement. XRD analysis was carried out by Malvern Panalytical diffractometer. Fourier transform infrared spectroscopic analysis was carried out by FTIR 4700 spectrometer.

3. RESULTS AND DISCUSSION

3.1. UV-Vis analysis

UV-Vis spectroscopy is a widely used technique for characterizing silver nanoparticles. It provides valuable information about the electronic transitions and optical properties of nanoparticles. When silver nanoparticles are exposed to light, they interact with the electromagnetic field, causing the Collective emission of conduction electrons, so-called surface plasmon resonance (SPR). This resonance leads to a sharp absorption peak in the UV-Vis spectrum.[37] In this study SPR of AgNPs@pl was detected as 468 nm proving the formation of nanoparticles (Figure 1). The particle size and shape effected the position of the absorption peak. The observation of color change from yellow to dark brown during the reaction process indicated the AgNPs@pl formation. The UV-Vis spectrum presents the significant role of AgNO3 and the chemical compounds in the plant fruits for formation of silver nanoparticles.

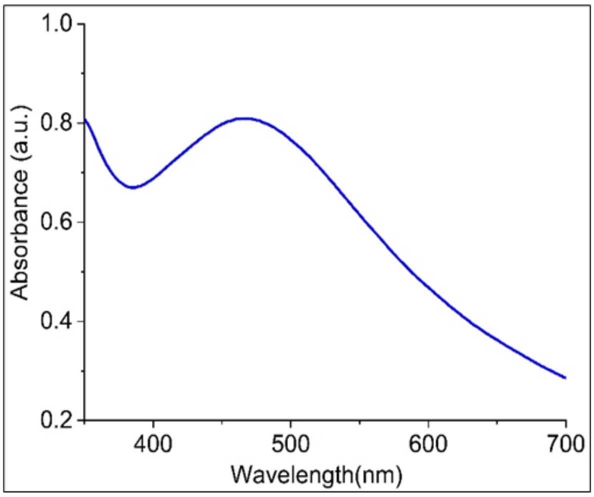

Figure 1. UV-Vis spectrum of AgNPs@pl.

DOI: http://dx.doi.org/10.32571/ijct.1341868 E-ISSN: 2602-277X

3.2. FTIR analysis

FTIR analysis is the significant technique to elucidate the natural compounds acting as reducing agent. The functional hydroxyl and carboxylic groups suggest the existence of phenolic and flavonoid in plant extract to reduce the nanoparticles.[38] The signals observed at 3248 cm-1, 2927 cm-1 and 1588 cm-1 correspond to the hydroxyl group of phenol or carboxylic acid, N-H stretching of amine, C=C stretching of alkene respectively. The other peaks, 1391 cm-1 and 1006 cm-1 might be due to the C-H bending of aldehyde and C=C bending of alkene respectively (Figure 2).

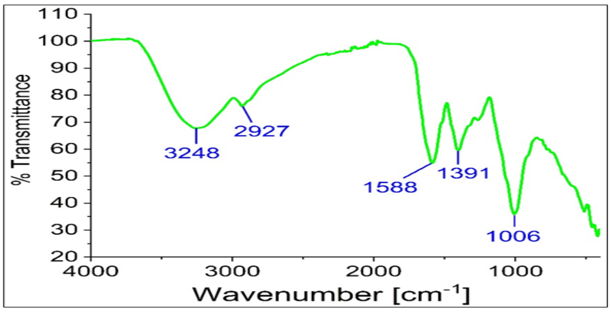

Figure 2. FTIR spectrum of AgNPs@pl.

3.3. TEM analysis

Transmission Electron Microscopy (TEM) is a powerful imaging technique to visualize the nanoscale structure of materials, including nanoparticles like silver nanoparticles. TEM provides high-resolution images that can reveal details about the size, shape, distribution, and arrangement of nanoparticles. TEM image revealed that AgNPs@pl were monodispersed, spherical in shape and 19 nm particle size (Figure 3). There was a consistency between the TEM image and the UV-Vis spectrum. Surface plasmon resonance in UV-Vis spectrophotometry indicated that the nanoparticles were in spherical shape.

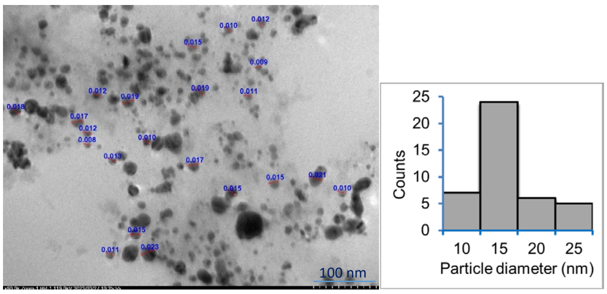

Figure 3. TEM image of AgNPs@pl and particle size distribution.

3.4. XRD analysis

XRD analysis displayed the crystal structure, purity, and particle size of silver nanoparticles. XRD analysis showed that the nanoparticles have face-centered cubic structure. The intense peaks at (2θ) 38.12, 44.32, 64.46, 77.42 related the lattice planes (111), (020), (202), (131) respectively (Figure 4). The highly crystalline and small size of AgNPs give rise to strong intensity and broadened diffraction peaks. The average size of AgNPs@Os was calculated using the Scherrer equation (Eq. 1) as 21 nm. There is a difference between the TEM value and XRD value. This may be due to the deviation of the spherical shape of the particles required for the Scherrer formula.[39]

$D = 0.9\,\lambda / \beta\cos\theta$ (1)

θ is the Braggs angle (degree), β is half maximum intensity as radian, λ is the wavelength of x-ray radiation, D is the diameter of the silver nanoparticles.

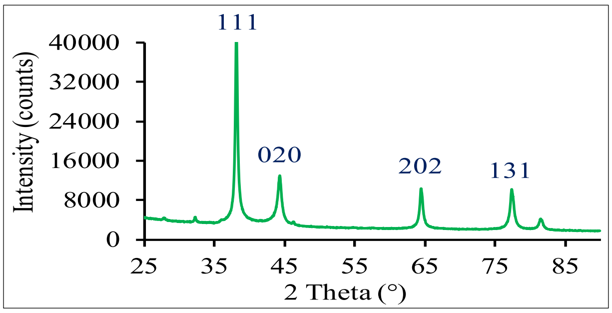

Figure 4. X ray diffraction of AgNPs@pl.

3.5. Zeta potential

The zeta potential of silver nanoparticles refers to the electric potential difference between the surface of the nanoparticles and the surrounding liquid medium.[40] It is a measure of the surface charge of the nanoparticles and is an important parameter in understanding their stability, dispersion, and interaction with other particles or surfaces in a liquid. Zeta potential is typically measured in millivolts (mV) and can be positive or negative, depending on whether the surface of the nanoparticles carries a net positive or negative charge.

The magnitude of the zeta potential provides insights into the electrostatic repulsion between particles; higher absolute values of zeta potential often indicate better stability, as particles with larger zeta potentials are less likely to aggregate. In this study, high negative ζ potential (-16.5 mV) displayed the stability of AgNPs@pl (Figure 5).

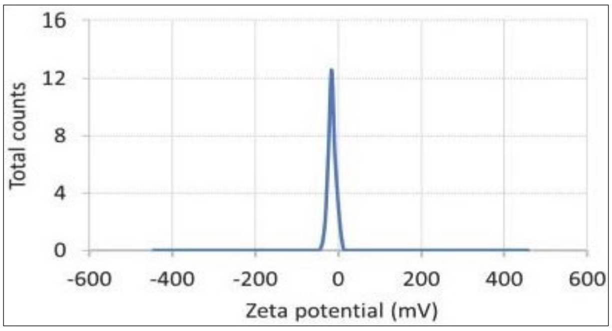

Figure 5. Zeta potential of AgNPs@pl

4. CONCLUSION

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Silver nanoparticles were synthesised using *Prunus laurocerasus* L. fruits extract by eco-friendly, easy, low-cost, reproducible manner. The characterization of green synthesized nanoparticles was achieved by spectroscopic techniques. *Prunus laurocerasus* L. fruits consist of bioactive compounds responsible of reducing, stabilizing, and capping agent. FTIR analysis confirmed the presence of phenolics and flavonoids in this fruit extract. *Prunus laurocerasus* L. fruits could be an excellent reducing agent for silver nanoparticle synthesis. In addition, the potential for use in the food and pharmaceutical industry should be studied.

Conflict of interests

The authors declare that there is no conflict of interest..

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