Journal of Academic Research Vol 30, Issu 1, 2026 "33-42"

The Libyan Academy
Misurata Branch

# Preparation of gold Nanoparticles Using a Green Method with Papaya Leaf Extract and Characterization Using UV-Vis, FTIR and XRD

**Salima M. Farhat[1], Adel M. Mlitan[2], and Ali M. Alhalib[3]**

[1,3] Chemisty Department, Faculty of Science, Alasmariya University, Zliten, Libya.

[1] Chemisty Department, Faculty of Science, Misurata University, Misurata, Libya.

adel_mlitan@sci.misuratau.edu.ly

**Article information**

**Key words**
Gold nanoparticles/ papayaleaf extract/ UV-Vis/ FTIR/XRD.

Received **08 01 2026**, Accepted **24 01 2026**, Available online **26 01 2026**

**Abstract**

Green synthesis of gold nanoparticles (AuNPs) has gained popularity as an economical and eco-friendly substitute for traditional chemical processes. Papaya leaf extract was used in this work as a natural reducing and stabilizing agent to create gold nanoparticles. When papaya leaf aqueous extract and chloroauric acid solution were combined under moderate reaction conditions, the synthesis of AuNPs was verified by a noticeable color shift. X-Ray Diffraction (XRD), ultraviolet–visible (UV–Vis) spectroscopy and Fourier transform infrared spectroscopy (FTIR) were used to analyze the produced gold nanoparticles. A distinctive surface plasmon resonance (SPR) absorption band at 520–550 nm was found by UV–Vis examination, demonstrating the stability and successful production of gold nanoparticles. The XRD patterns showed the strong crystallinity of the biosynthesized nanoparticles and verified the face-centered cubic (FCC) structure of gold, FTIR analysis confirmed the presence of phytochemicals from Carica papaya leaf extract as capping agents. The findings show that papaya leaf extract works well as a green agent for producing gold nanoparticles without the usage of hazardous substances.

## I. Introduction

The 21st century saw the scientific breakthrough of nanotechnology. Because of their intriguing biological, physical, chemical, magnetic, and optical characteristics, metallic nanoparticles have become incredibly popular. Many physical, chemical, and biological techniques can be used to create metal-based nanoparticles. [1,2]

Nanoparticles are biosynthesized using the metabolic byproducts of microorganisms (bacteria, fungi, algae) or plant extracts. This method is environmentally friendly, energy-efficient, inexpensive, and fast. [3]



s.farhat@sci.asmarya.edu.ly
.

A previous study indicated that sub-micron particles are more efficiently absorbed by cells compared to larger particles in medical and therapeutic applications. [4]

The green synthesis of AuNPs using plant extracts has gained significant attention as an eco-friendly and cost-effective alternative to conventional chemical methods. [5,6] This approach harnesses the reducing and capping abilities of plant-derived biomolecules, potentially imparting additional bioactive properties to the nanoparticles. [7,8]

Carica Papaya, commonly known as the papaya, is a member of the Caricaceae family which also contains six genera: Carica, Garella, Horovetsia, Jacaratia, Vasconcela, and Selikomorpha. The papaya belongs to the genus Carica, which includes only one species Carica papaya.[9] is a tropical fruit tree with a rich history of medicinal use.[10] Various parts of the plant, including leaves, have been traditionally employed for their anti-inflammatory antioxidant and potential anticancer properties. [11,12] The leaves of Carica papaya contain a complex mixture of bioactive compounds including flavonoids, alkaloids, and phenolic acids which may contribute to its therapeutic effects. [13,14]

The nutrients found in papaya leaf extracts consist mostly of macromolecules such as proteins, fats carbohydrates, and essential minerals including potassium, phosphorus magnesium, iron calcium and dietary fiber, as well as vitamins such as vitamin C vitamin B1 vitamin B2, vitamin B3, and beta-carotene. [15]

In order to confirm nanoparticle formation and identify the functional groups involved in the reduction and stabilization processes, this study aims to prepare gold nanoparticles using an environmentally friendly green synthesis method based on papaya (Carica papaya) leaf extract as a natural reducing and stabilizing agent. The produced nanoparticles will then be characterized using UV–Vis, X-Ray Diffraction (XRD) and Fourier transform infrared spectroscopy (FTIR) [16,17]

By employing papaya leaf extract to create gold nanoparticles in an environmentally friendly and economical manner and by combining UV-Vis, XRD and FTIR analysis to provide light on the function of plant biomolecules in nanoparticle synthesis, this work advances green nanotechnology. [18,19]

## II. Methodology

A. Green Synthesis of Gold Nanoparticles (AuNPs)

1. Plant Material Preparation:

Fresh Carica papaya leaves were collected from local plantations in Zliten- Libya, authenticated by a botanist, and washed thoroughly with deionized water. The leaves were air-dried at room temperature for 7 days, then pulverized into a fine powder using a mechanical grinder (Blade Grinder CBG100S Cuisinart, USA). The powder was stored in airtight containers at 4°C until further use[20].

2. Extract Preparation:

Aqueous extraction was performed by mixing 10 g of leaf powder with 100 mL of deionized water. The mixture was heated at 60°C for 30 minutes under constant stirring using a hot plate magnetic stirrer (MS-H-Pro+, Scilogex, USA). The resulting solution was filtered through Whatman No. 1 filter paper and centrifuged at 10,000 rpm for 15 minutes using a high-speed centrifuge (Sorvall Legend X1R, Thermo Fisher Scientific, USA). The supernatant was collected and stored at 4°C for further use[20] .

3. AuNP Synthesis:

The synthesis of AuNPs was carried out by adding the Carica. papaya leaf extract to 1 mM chloroauric acid (HAuCl4) solution (Sigma-Aldrich, USA) in a 1:9 ratio. The reaction mixture was incubated at room temperature under constant stirring for 24 hours using a magnetic stirrer (MS-H-Pro+, Scilogex, USA). The formation of AuNPs was indicated by a color change from pale yellow to deep purple. [20]

B. Characterization of AuNPs

**1. X-Ray Diffraction (XRD):**

Crystalline nature and phase purity of the synthesized AuNPs were analyzed using an X-ray diffractometer (D8 Advance, Bruker, Germany) with Cu Kα radiation (λ = 1.54 Å) in the 2θ range of 20°-80°. The operating voltage and current were set at 40 kV and 40 mA, respectively. [21]

**2. UV-Visible Spectroscopy:**

The optical properties and formation of AuNPs were monitored using a UV-visible spectrophotometer (UV-2600, Shimadzu, Japan) in the range of 300-800 nm. Measurements were performed at room temperature using quartz cuvettes with a 1 cm path length. [22]

**3. Fourier Transform Infrared Spectroscopy (FTIR):**

FTIR analysis was performed to identify the functional groups involved in the reduction and stabilization of AuNPs. Spectra were recorded on an FTIR spectrometer (Nicolet iS50, Thermo Fisher Scientific, USA) in the range of 4000-400 cm^-1 with a resolution of 4 cm^-1.[23]

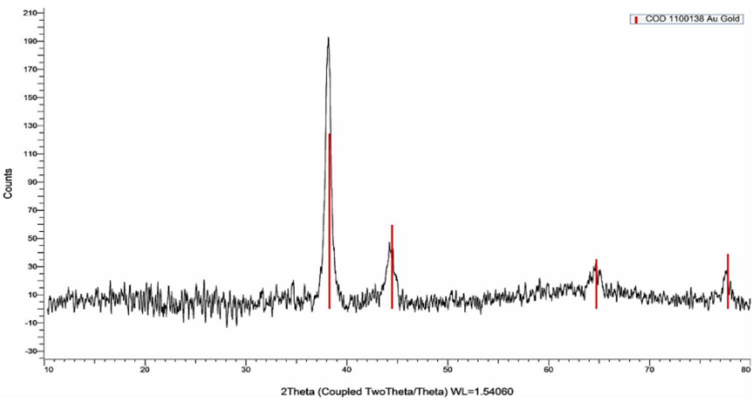
## III.Results and Discussion

A. Characterization of Gold Nanoparticles

1. X-Ray Diffraction (XRD) Analysis:

The crystalline nature and purity of the synthesized AuNPs were investigated using X-ray diffraction analysis. [24] Figure (1) presents the XRD pattern of the green-synthesized AuNPs.

**Figure 1: XRD pattern of green-synthesized AuNPs**



The XRD pattern exhibited sharp and intense peaks indicating the high crystallinity of the synthesized AuNPs. The prominent diffraction peaks were observed at 2θ values of 38.87°, 45.18°, 65.75° 78.97°, corresponding to the (111), (200), (220), (311), planes of the face-centered cubic lattice structure of gold, respectively. These peaks closely match the standard diffraction pattern of gold (JCPDS file no. 04-0784), confirming the successful formation of crystalline AuNPs. [24]

In contrast to the other planes, the strong (111) reflection indicates that the synthesized AuNPs have a predominate orientation. The nanoparticles' surface characteristics and reactivity may be influenced by this preferred orientation, which might improve their biological and catalytic capabilities. The development of well-crystallized nanoparticles with few lattice flaws or strain is indicated by the crisp and narrow diffraction peaks.

The XRD pattern's lack of extra peaks attests to the produced AuNPs' excellent purity and lack of crystalline impurities. For constant physicochemical characteristics and dependable performance in prospective applications, this purity is essential. The average crystallite size of the AuNPs was calculated using the Scherrer equation to be around 25 nm. This estimate serves as a preliminary measure of the nanoparticle dimensions, which will be confirmed by other characterization methods.[24]

2. UV-Visible Spectroscopy

The formation and optical properties of green-synthesized AuNPs using Carica papaya leaf extract were confirmed by UV-Visible spectroscopy [24] Figure (2) shows the UV-Visible absorption spectrum of the colloidal AuNP solution.

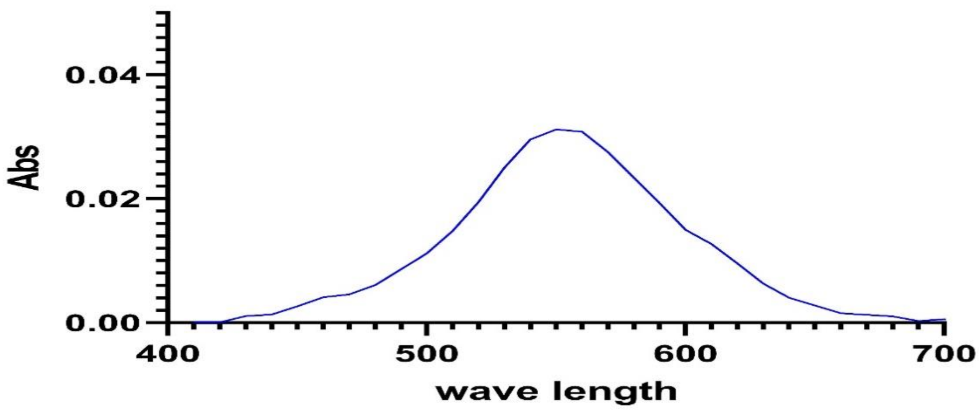



Figure 2: UV-Visible absorption spectrum of green-synthesized gold nanoparticles.

The UV-Visible spectrum displayed a characteristic surface plasmon resonance (SPR) band with a maximum absorption peak at approximately 558.6 nm, which is typical for spherical gold nanoparticles. This observation confirms the successful synthesis of AuNPs using the green method. The presence of a single, sharp SPR peak indicates a narrow size distribution of the nanoparticles and suggests minimal aggregation in the colloidal solution.

Particle size, shape, and the dielectric constant of the surrounding medium are some of the variables that affect the location and form of the SPR band. The XRD-derived crystallite size and published findings for comparable green synthesis techniques are in agreement with the observed peak at 558.6 nm, which is compatible with the creation of spherical AuNPs within the size range of 20–60 nm. [24]

The concentration of AuNPs in the solution may be inferred qualitatively from the strength of the SPR peak. The spectrum displays a gradual increase in absorbance towards shorter wavelengths, which can be attributed to the interband transitions of gold. However, the relatively high absorbance value (approximately 0.05) indicates a substantial yield of nanoparticles from the green synthesis process suggesting an efficient reduction of gold ions by the Carica papaya Leaf extract. The creation of mostly spherical nanoparticles with negligible anisotropic morphologies is suggested by the lack of extra peaks or shoulders in the visible area. The existence of a bio-organic corona formed from the plant extract and the nanoparticles' polydispersity may be the cause of the small widening of the SPR peak when compared to chemically manufactured AuNPs. The overall stability and biocompatibility of the nanoparticles are probably enhanced by this corona.

These findings are quite similar to those of Wehbe et al. (2025) [24] who similarly produced AuNPs in an environmentally friendly manner using Halodule uninervis extract. The UV–Visible absorption peak, which was also seen in their studies at around 550 nm, suggested the formation of spherical nanoparticles within a comparable size range. Both studies show how the phytochemicals from H. uninervis can act as reducing and stabilizing agents, promoting the ecologically safe production of biocompatible, widely dispersed AuNPs. Wehbe et al. emphasized the biological potential of such particles, particularly their anticancer activity, and stated that the structural and optical properties obtained by this synthesis procedure are beneficial for therapeutic applications.

3. Fourier Transform Infrared Spectroscopy (FTIR):

The Fourier transform infrared spectrum of the extract of *Carica papaya* leaves before the synthesis of gold nanoparticles was analyzed. The figure (16a) shows the spectrum of the leaf extract and The Fourier-Transform Infrared (FTIR) spectrum of the synthesized gold nanoparticles using Carica papaya leaf extract was analyzed to identify the functional groups responsible for the reduction and stabilization of the nanoparticles. The spectrum shown in the figure(16b) reveals several characteristic peaks that provide insights into the biomolecules involved in the green synthesis process.

1. 3291.48 $cm^{-1}$: A broad, strong peak indicative of O-H stretching vibrations, likely from phenolic compounds and alcohols present in the Carica papaya leaf extract.
2. 2919.79 $cm^{-1}$: This peak can be attributed to C-H stretching vibrations of alkanes, suggesting the presence of organic compounds from the plant extract.
3. 2050.73 $cm^{-1}$: A weak peak that could be associated with C≡N stretching or cumulated double bonds (C=C=C), possibly from alkaloids or other nitrogen-containing compounds in the extract.
4. 1600.92 $cm^{-1}$: This strong peak is characteristic of C=C stretching in aromatic rings and/or C=O stretching in amide groups (Amide I band), indicating the presence of flavonoids or proteins.
5. 1383.78 $cm^{-1}$: Likely corresponds to C-H bending of alkanes or O-H bending of phenols.
6. 1237.37 $cm^{-1}$: This peak can be attributed to C-O stretching vibrations in phenols, ethers, or esters.
7. 1031.41 $cm^{-1}$: A strong peak indicative of C-O stretching vibrations in alcohols, carboxylic acids, esters, or ethers.

8. 529.85 $cm^{-1}$: This peak in the fingerprint region could be associated with metal-oxygen bonds, potentially indicating the interaction between gold nanoparticles and oxygen-containing functional groups from the biomolecules.

The FTIR spectrum provides valuable information about the biomolecules from Carica papaya leaf extract that are involved in the reduction of gold ions and the stabilization of the resulting nanoparticles:

1. **Phenolic Compounds and Flavonoids**: The strong peaks at 3291.48 $cm^{-1}$ (O-H stretching) and 1600.92 $cm^{-1}$ (aromatic C=C stretching) suggest the presence of phenolic compounds and flavonoids. These molecules are known for their strong antioxidant properties and can act as reducing agents in the synthesis of gold nanoparticles.
2. **Proteins and Peptides**: The peak at 1600.92 $cm^{-1}$ could also indicate the presence of amide bonds from proteins. Proteins can act as capping agents, stabilizing the nanoparticles and preventing aggregation.
3. **Carbohydrates**: The strong peak at 1031.41 $cm^{-1}$ (C-O stretching) suggests the presence of carbohydrates, which can also contribute to the reduction process and stabilization of nanoparticles.
4. **Alkaloids**: The weak peak at 2050.73 $cm^{-1}$ might indicate the presence of alkaloids, which are nitrogen-containing compounds that could contribute to the reduction process.
5. **Nanoparticle-Biomolecule Interaction**: The peak at 529.85 $cm^{-1}$ in the fingerprint region could signify the interaction between gold nanoparticles and oxygen-containing functional groups from the biomolecules, suggesting effective capping and stabilization of the nanoparticles.

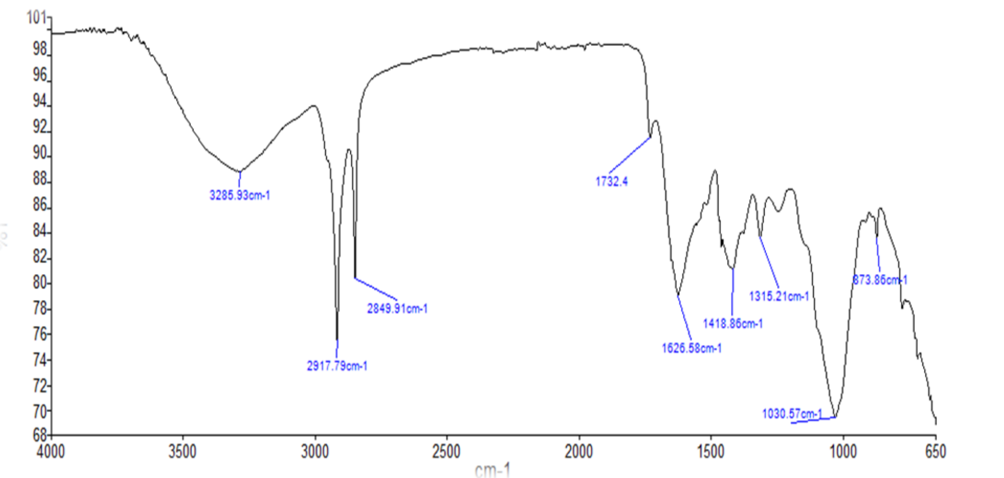



**Figure 3a: illustrated FTIR pattern before gold nanoparticles**

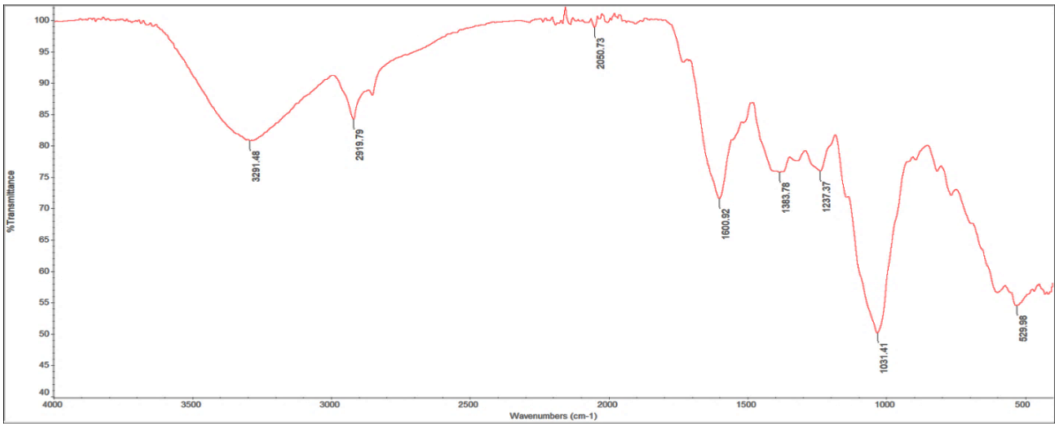



**Figure 3b: illustrated FTIR of AuNPs green synthesis.**

The presence of these diverse functional groups indicates that multiple biomolecules from the Carica papaya leaf extract are involved in the green synthesis process. The phenolic compounds and flavonoids likely play a crucial role in reducing gold ions to nanoparticles, while proteins and carbohydrates may act as capping agents, providing stability to the synthesized nanoparticles.

In conclusion, the FTIR analysis confirms the successful green synthesis of gold nanoparticles using Carica papaya leaf extract and provides insights into the biomolecules responsible for the reduction, stabilization of the synthesized nanoparticles. This eco-friendly approach not only offers a simple and sustainable method for nanoparticle synthesis but also imparts beneficial properties to the nanoparticles through the natural capping agents derived from the plant extract. [25]

## IV.Conclusion

The study's findings showed that papaya (Carica papaya) leaf extract may be used as a natural reducing and stabilizing agent to successfully synthesize gold nanoparticles in an environmentally friendly manner. The produced nanoparticles showed consistent and unique structural and optical characteristics. The development of a distinctive surface plasmon resonance band in UV–visible spectroscopy showed the creation of gold nanoparticles, and X-ray diffraction (XRD) examination validated the nanoparticles' high crystallinity and face-centered cubic (FCC) crystal structure, The involvement of phytochemicals from Carica papaya leaf extract in the reduction and stabilization of AuNPs was confirmed through FTIR analysis.These results demonstrate papaya leaf extract's efficacy in green synthesis, which makes it a secure and sustainable substitute for traditional chemical techniques.

Based on the findings, further research is advised to assess the biological activities of gold nanoparticles and define their size and structure using sophisticated imaging methods like SEM and TEM. In order to broaden their biological, environmental, and catalytic uses, it is also recommended to perform comparative studies with other plant extracts, evaluate the viability of large-scale production, and fine-tune green synthesis parameters to regulate particle size and stability.

## V. References

[1]. A. Bukhari, I. Ijaz, E. Gilani, A. Nazir, H. Zain, R. Saeed, S. S. Alarfaji, S. Hussain, R. Aftab, and Y. Naseer, “Green synthesis of metal and metal oxide nanoparticles using different plants’ parts for antimicrobial activity and anticancer activity: A review,” Coatings, vol. 11, no. 11, Art. no. 1374, 2021, doi: 10.3390/coatings11111374.

[2]. P. V. Nagime and V. S. Chandak, “A comprehensive review of nanomaterials synthesis: Physical, chemical, and biological approaches and emerging challenges,” Biocatalysis and Agricultural Biotechnology, vol. 62, Art. no. 103458, 2024, doi: 10.1016/j.bcab.2024.103458.

[3]. [ J. J. K. Ribeiro, P. S. da Silva Porto, R. D. Pereira, and E. P. Muniz, “Green synthesis of nanomaterials: Most cited papers and research trends,” Research, Society and Development, vol. 9, no. 1, 2020.

[4]. S. Nimesh, R. Chandra, and N. Gupta, Advances in Nanomedicine for the Delivery of Therapeutic Nucleic Acids. Cambridge, U.K.: Woodhead Publishing, 2017.

[5]. K. K. Bharadwaj et al., “Green synthesis of gold nanoparticles using plant extracts as beneficial prospect for cancer theranostics,” Molecules, vol. 26, no. 21, Art. no. 6389, 2021, doi: 10.3390/molecules26216389.

[6]. L. Castillo-Henríquez et al., “Green synthesis of gold and silver nanoparticles from plant extracts and their possible applications as antimicrobial agents in the agricultural area,” Nanomaterials, vol. 10, no. 9, Art. no. 1763, 2020, doi: 10.3390/nano10091763.

[7]. F. Al-Sarraj et al., “Green synthesis of chitosan-capped gold nanoparticles using Salvia officinalis extract: Biochemical characterization and antimicrobial and cytotoxic activities,” Molecules, vol. 28, no. 23, Art. no. 7762, 2023, doi: 10.3390/molecules28237762.

[8]. P. B. Santhosh, J. Genova, and H. Chamati, “Green synthesis of gold nanoparticles: An eco-friendly approach,” Chemistry, vol. 4, no. 2, pp. 345–369, 2022, doi: 10.3390/chemistry4020026.

[9]. P. Burns, P. Saengmanee, and U. Doung-Ngern, Papaya: The Versatile Tropical Fruit. Bangkok, Thailand: National Center for Genetic Engineering and Biotechnology (NSTDA), 2023, doi: 10.5772/intechopen.104624.

[10]. R. Srivastava, N. Jaiswal, H. Kharkwal, N. K. Dubey, and R. Srivastava, “Against viral infections,” Viruses, vol. 17, no. 2, Art. no. 271, 2025, doi: 10.3390/v17020271.

[11]. A. Sharma et al., “Carica papaya L. leaves: Deciphering its antioxidant bioactives, biological activities, innovative products, and safety aspects,” Oxidative Medicine and Cellular Longevity, vol. 2022, Art. no. 2451733, 2022, doi: 10.1155/2022/2451733.

[12]. S. P. Singh et al., “Therapeutic application of Carica papaya leaf extract in the management of human diseases,” DARU Journal of Pharmaceutical Sciences, vol. 28, no. 2, pp. 735–744, 2020, doi: 10.1007/s40199-020-00348-7.

[13]. R. Choudhary et al., “Nutritional, phytochemical, and antimicrobial properties of Carica papaya leaves: Implications for health benefits and food applications,” Foods, vol. 14, no. 2, Art. no. 154, 2025, doi: 10.3390/foods14020154.

[14]. A. N. E. Hamed et al., “Chemical constituents from Carica papaya Linn. leaves as potential cytotoxic, EGFRwt and aromatase (CYP19A) inhibitors,” RSC Advances, vol. 12, no. 15, pp. 9154–9162, 2022, doi: 10.1039/d1ra07000b.

[15]. D. Dimitrios et al., “Phytochemical screening of Psidium guajava and Carica papaya leaves aqueous extracts cultivated in Greece and their potential as health boosters,” Exploration of Foods and Foodomics, pp. 5–14, 2023, doi: 10.37349/eff.2023.00002.

[16]. V. Amendola et al., “Surface plasmon resonance in gold nanoparticles: A review,” Journal of Physics: Condensed Matter, vol. 29, no. 20, Art. no. 203002, 2017.

[17]. E. Boisselier and D. Astruc, “Gold nanoparticles in nanomedicine: Preparations, imaging, diagnostics, therapies and toxicity,” Chemical Society Reviews, vol. 38, no. 6, pp. 1759–1782, 2009.

[18]. S. Sunkari et al., “Microwave-irradiated green synthesis of gold nanoparticles for catalytic and antibacterial activity,” Journal of Analytical Science and Technology, vol. 8, Art. no. 13, 2017.

[19]. M. A. Alghuthaymi et al., “Green synthesis of gold nanoparticles using Polianthes tuberosa L. floral extract,” Plants, vol. 10, no. 11, Art. no. 2370, 2021, doi: 10.3390/plants10112370.

[20]. T. A. Sathya et al., “Environmental profiling of gold nanoparticles by flavonoids fractionalization from Carica papaya leaf extract for photocatalytic degradation of organic contaminants and cytotoxic analysis,” Environmental Research, vol. 259, Art. no. 119445, 2024, doi: 10.1016/j.envres.2024.119445.

[21]. M. Barasinski et al., “In situ tracking of nanoparticles during electrophoresis in hydrogels using a fiber-based UV–Vis system,” Nanomaterials, vol. 4, no. 1, Art. no. 3, 2025.

[22]. S. Malik et al., “Cytotoxicity study of gold nanoparticle synthesis using Aloe vera, honey, and Gymnema sylvestre leaf extract,” ACS Omega, vol. 8, no. 7, pp. 6325–6336, 2023, doi: 10.1021/acsomega.2c06491.

[23]. A. M. Pinilla-Torres, C. N. Sanchez-Dominguez, K. Basilio-Bernabe, P. Y. Carrion-Garcia, J. A. Roacho-Perez, E. N. Garza-Treviño, H. Gallardo-Blanco, and M. Sanchez-Dominguez, “Green synthesis of mesquite-gum-stabilized gold nanoparticles for biomedical applications: Physicochemical properties and biocompatibility assessment,” Polymers, vol. 15, no. 17, Art. no. 3533, 2023, doi: 10.3390/polym15173533.

[24]. N. Wehbe et al., “Halodule uninervis extract facilitates the green synthesis of gold nanoparticles with anticancer activity,” Scientific Reports, vol. 15, no. 1, Art. no. 4286, 2025, doi: 10.1038/s41598-025-10822-z.

[25]. C. Vázquez-Morón, F. Serrano-Marugán, M. Orzáez, B. Suay-García, and J. López-Martínez, “Plant-based extracts as reducing, capping, and stabilizing agents for the green synthesis of inorganic nanoparticles,” Resources, vol. 13, Art. no. 70, 2024, doi: 10.3390/resources13050070.

**Preparation of gold nanoparticles using a green method with papaya leaf extract and characterization using UV-Vis and X-Ray Diffraction (XRD)**

# تحضير جزيئات الذهب النانوية باستخدام طريقة خضراء مع مستخلص أوراق البابايا وتوصيفها باستخدام الأشعة فوق البنفسجية - المرئية، والأشعة تحت الحمراء بتحويل فورريه وحيود الأشعة السينية

**سليمة محمد فرحات[1] ، عادل محمد مليطان[1]، علي محمد الهليب[2]**

[1، 2] قسم الكيمياء، كلية العلوم، الجامعة الأسمرية الإسلامية، زليتن، ليبيا.

[1] قسم الكيمياء، كلية العلوم، جامعة مصراته، مصراته، ليبيا.

**الملخص**

اكتسب التخليق الأخضر لجزيئات الذهب النانوية شعبيةً واسعةً كبديل اقتصادي وصديق للبيئة للعمليات الكيميائية التقليدية. استُخدم مستخلص أوراق البابايا في هذه الدراسة كعامل اختزال وتثبيت طبيعي لإنتاج جزيئات الذهب النانوية. عند مزج المستخلص المائي لأوراق البابايا مع محلول حمض الكلوروأوريك في ظروف تفاعل معتدلة، تم التحقق من تخليق جزيئات الذهب النانوية من خلال تغير ملحوظ في اللون. استُخدمت تقنية حيود الأشعة السينية ومطيافية الأشعة فوق البنفسجية المرئية لتحليل جزيئات الذهب النانوية المُنتجة. كشف فحص مطيافية الأشعة فوق البنفسجية المرئية عن وجود حزمة امتصاص مميزة لرنين البلازمون السطحي عند 520-550 نانومتر، مما يدل على استقرار جزيئات الذهب النانوية ونجاح إنتاجها. أظهرت أنماط حيود الأشعة السينية التبلور القوي للجزيئات النانوية المُصنّعة حيويًا، وأكدت بنية الذهب المكعبة ذات المراكز الوجهية، كما أكد تحليل طيف الأشعة تحت الحمراء وجود مواد كيميائية نباتية من مستخلص أوراق البابايا كعوامل تغليف. تُظهر النتائج أن مستخلص أوراق البابايا يُعدّ عاملاً صديقاً للبيئة لإنتاج جزيئات الذهب النانوية دون استخدام مواد خطرة. تُبرز هذه التقنية الصديقة للبيئة الإمكانيات الكبيرة لاستخدام جزيئات الذهب النانوية في مجالات الطب الحيوي، والحفز، والبيئة، وذلك من خلال توفير عملية بسيطة ومستدامة وقابلة للتطوير.

**الكلمات المفتاحية**
جسيمات الذهب النانوية، مستخلص أوراق البابايا، الأشعة فوق البنفسجية المرئية، الأشعة تحت الحمراء، حيود الأشعة السينية