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Preparation of (Au_2O) By Green Synthesis

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Abstract: Since the increased drug efficacy and lower toxicity in nano-mediateddrug delivery model have led to various applications in current science, the ecologically friendly synthesis regarding nanoparticles (NPs) by the green route from plant extracts has gained favor. In the presented work, we looked into the biosynthesis regarding goldoxide nanoparticles (NPs) from Au2O NPs green tea that are both stable and reasonably priced. The approach used for preparing Au NPs using green synthesis is demonstrated in this work to be straightforward and affordable. This was accomplished by combining an aqueous solution of goldnitrate with an olive extract, and visual spectroscopy as well as color change were employed to demonstrate the preparation ofAu2O NPs. Through using UV spectroscopy, the nature regarding the synthesized AgNPs was determined to be 2.5 mM. According to the research,aqueous extract is a good material for makingAu2O NPs, and by modifying the factors influencing this study, moreAu2ONPs in smaller sizes could be produced. After that, it was established that the extracted gold oxide had antibacterial characteristics, allowing it to be employed in a variety of pharmaceutical preparations for treating infections brought on by both negative and positive bacteria. As it wasdemonstrated to have a bactericidal effect on bacteria like the ones utilized in this research-namely, Staphylococcus aureus Staphylococcus pneumoniae, and Escherichi

Keywords: Au2O NPs, nanostructure, green tea, bacteria, XRD examination

1. Introduction

A viable substitute for traditional chemical and physical processes, the green synthesis regarding gold nanoparticles (AuNPs) provides an economical, sustainable, and environmentally beneficial method. Green synthesis uses natural biological resources including plant extracts, microorganisms, and other bio-based materials as reducing and stabilizing agents, in contrast to conventional synthesis methods that frequently use toxic chemicals and excessive energy consumption. Plant-based green synthesis, in particular, has garnered significant attention due to the simplicity of the process and the rich variety of bioactive compounds present in plant extracts, including phenolics, flavonoids, alkaloids, and terpenoids. These phytochemicals facilitate the reduction of gold ions (Au^{3+}) to elemental gold (Au^0) and simultaneously stabilize the nanoparticles, preventing agglomeration .The process typically involves mixing an aqueous solution of gold salts[1], such as chloroauric acid ($HAuCl_4$), with a plant extract under controlled conditions. The visible color change, usually from pale yellow to ruby red or purple, indicates the formation of gold nanoparticles due to surface plasmon resonance . Green synthesis is not only environmentally benign but also advantageous for biomedical applications, as the biologically synthesized AuNPs tend to exhibit enhanced biocompatibility and lower toxicity compared to their[2] chemically synthesized counterparts.Gold oxides are less common compared to other metal oxides due to gold's noble character, but several gold oxides have been identified and studied. Below are the key properties of gold oxides, primarily focusing on gold(I) oxide (Au_2O) and gold(III) oxide (Au_2O_3),

Gold(I) Oxide (Au_2O)

- Formula: Au_2O
  Appearance: Dark purple or brownish-black powder
- Stability: Unstable at room temperature, decomposes to Au and O_2 above ~200°C
- Solubility: Insoluble in water, decomposes in acids
- Crystal Structure: Poorly defined due to instability; may have a linear O-Au-Au-O structure[3]
- Preparation: Formed by the reaction of AuCl with alkali hydroxides under controlled conditionsChemical Behavior: Acts as a precursor in some gold chemistry reactions but is not a major industrial compound

Gold(III) Oxide (Au_2O_3)

- Formula: Au_2O_3
- Appearance: Brown or dark brown powder
- Stability: More stable than Au_2O but still decomposes at ~150–250°C into Au and O
- Solubility: Insoluble in water, reacts with strong acids to form Au(III) salts

- Crystal Structure: Amorphous or poorly crystalline; may have a hexagonal structure
- Preparation: Typically obtained by heating $Au(OH)_3$ or by ozonizing Au in acidic solutions[4]
- Chemical Behavior: Used in some catalytic and electrochemical applications

Gold Hydroxides (AuOH) and $Au(OH)_3$

- Gold(I) Hydroxide (AuOH): Highly unstable, tends to dehydrate into Au_2O
- Gold(III) Hydroxide ($Au(OH)_3$): More stable, used as an intermediate to produce Au_2O_3
- Electronic and Catalytic Properties
- Gold oxides are semiconducting and have been explored in sensors and catalysis (e.g., CO oxidation) [4,5]

2. Properties of Gold Oxide Nanoparticles

Catalytic activity: Useful in oxidation reactions and environmental remediation.
Antimicrobial properties: Effective against various bacterial strains.
Optical properties: Unique due to surface plasmon resonance[6]

- Stability and biocompatibility: Enhanced when prepared via green synthesis due to surface coating by natural compounds - .Au_2O_3 nanoparticles show potential in photocatalysis and electrochemical applications [7].

3. Materials and Method Preparation of Plant Extract

Hotplate, Beaker, gold nitrate Au(NO3)3 solution, test tube,green tea, water

1. Add Au(NO3)3 of (9 gm) in distilled water of (100 ml.1
2. The mixture is put on hotplate.
3. The green tea are put in distilled water of (100) ml.
4. After that, put it on hotplate for 1 hr.
5. Them, put the Au(NO3)3 solution to green tea.
6. After period of time we get gold oxide NPs.

Sigma-Aldrich chemicals provided the Au(NO3)3, which has been utilized exactly as it was received. The water used for all of the reactions was deionized. After being cleaned with distilled water and diluted nitric acid HNO3, all glass items have been dried in a hot air oven. For obtaining the extract, 2g of green teabroth has been cooked for 15min., filtered, and then completed to 100ml. To be utilized within a week, the filtrate that has been utilized as a reducing agent has been stored at 10 °C in the dark. Au(NO3)3 (2×10^{-2} M) was made as a stock solution through dissolving (0.34g/100ml) of deionized water

Fig (1)

4. Biological

One dynamic, safe, and energy-efficient way to create NPs is through biological synthesis. For synthesizing NPs in vivo, this method uses a variety of biological resources, including eukaryotes and prokaryotes. These sources contain metabolites (fatty acids, proteins, enzymes, sugars, and phenolic compounds) that are essential to the stability regarding metallic ions as well as their bio-reduction to NPs. The stability of AuNPs produced biologically is higher than that of those produced otherwise. Although AuNPs could be produced effectively using chemical processes, the primary danger is the production of secondary products, or by-products, that pose a threat to both the environment and human health. Various biological systems, including yeasts, bacteria, plants, and fungi, are thus actively investigating new pathways for the generation of safe nanoproducts in order to make AuNPs (Teimouri et al., 2018) [9]).

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5. Green synthesis of plant extract -AuNPs

In comparison to other ecologically friendly biological approaches, the abundance of plants found in nature has the advantages of high reproducibility, low cost, eco-friendliness, and exact purification [10]. Recently, there has been a surge in interest in green methods that use plant extracts as stabilizing agents and reducing agents to prepare AuNPs because of their several [11] benefits (Fu et al., 2017; Qi and Qiao, 2021).

6. The Results

1.6 XRD measurement

XRD analysis, strong peaks of the thin film (AU2O nano structure) in a polycrystalline structure are shown by XRD analysis in Fig 2. The XRD pattern of AU2O NSs placed on a glass substrate is displayed in Fig(2). Through comparing with the conventional pattern (JCPDS), it displays aVerysharp peak at (13.98) on the 2theta scale associated with rhombohedralgold oxideand other peak at(25.66), which provides proof of the creation of AU2O

Through using Debye Scherrer's relation, crystallite size could be calculated [20].

$$G_s = \frac{0.9\ \lambda}{\beta \cos(\theta)} \quad (1)$$

θ denotes the diffraction angle, β denotes FWHM, and λ denotes the x-ray wave-length.

Equations (2&3) could be utilized for the evaluation regarding the density of the disarrangement δand strain η [13,14], as can be seen from table1:

$$\eta = \frac{\beta \cos \theta}{4} \quad (2)$$

$$\delta = \frac{1}{{G_s}^2} \quad (3)$$

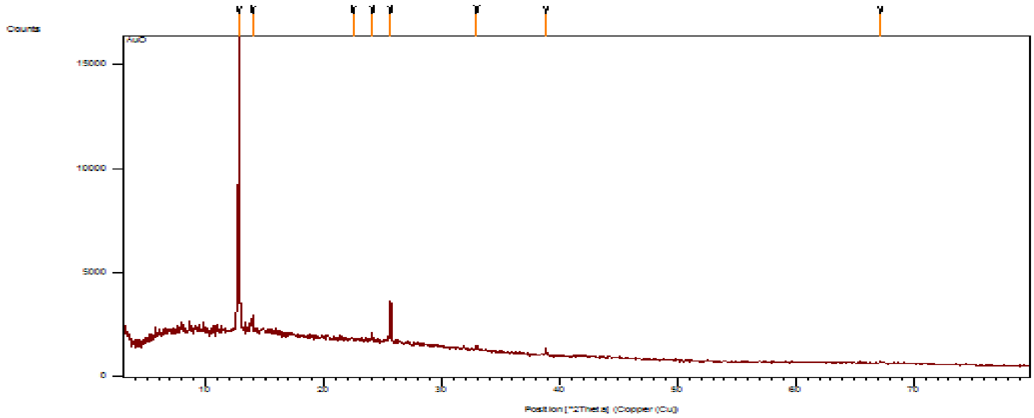

Fig 2: The XRD pattern of Au_2O NPs

Sample	**2 thetas (deg)**	**G_s (nm)**	**η (lines^{-2}.m^{-4})**	**δ10^{17}(lines.m^{-2})**
Au	13.98	43.78	4.16	.07
	25.66	37.22	10.85	0.4 97

Table 1: The values of the FWHM, grain size, the strain (δ) and dislocating density (η).

2.6 Scanning electron microscopy (SEM):

Figure 3 displays the SEM of gold oxide nanoparticles. We see that the formation of nanoscale gold oxide is complete, displaying the fine structure and particle clumping. With nanoscale sizes ranging from (26 to 33) nm, they possessed a regular, uniform shape and a hexagonal structure, but sometimes they appeared to have a spiral structure.

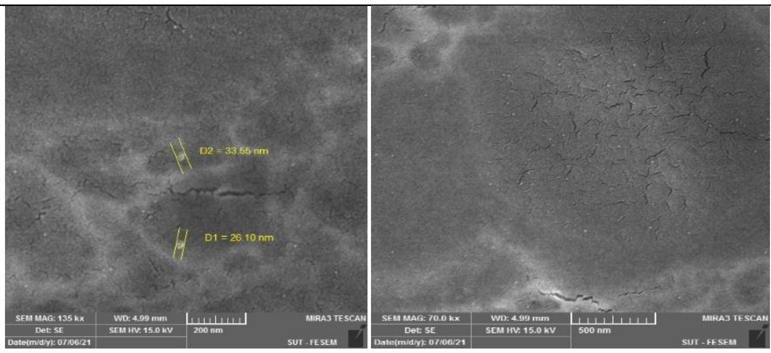

Fig. 3: SEM images of Au2O

3.6 Optical Properties

Au2O is shown to be in Fig (4). indicating that the corresponding electron changes occurring within the sample are the cause of the ultraviolet absorption. It is also evident from this figure that the transmittance increases with wavelength (350 nm), At wavelengths of(600-1100)nm, the transmission spectrum is almost stable.

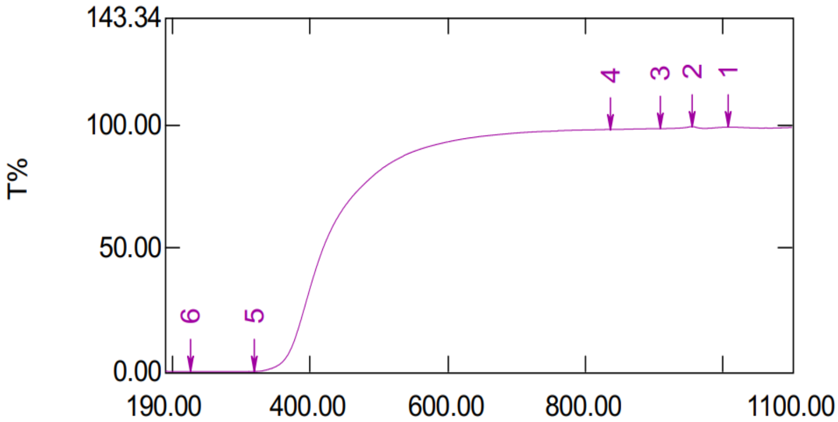

Fig 4: The transmission spectrum

4.6 Fourier Transform:

The possible functional groups that are in charge of the gold oxide nanoparticles have been identified using FTIR spectroscopy. Au2o spectra that were extracted from green tea extract are shown in Figure 6. The peaks that correspond to symmetrical and asymmetrical –CH group stretching are located around (480, 670.38, 1452.68, and 3488.11, 3845) cm^{-1}. At 3488 cm^{-1} (both without and with a ligand cap), the distinctive peaks that represent the O–H acid group are visible.

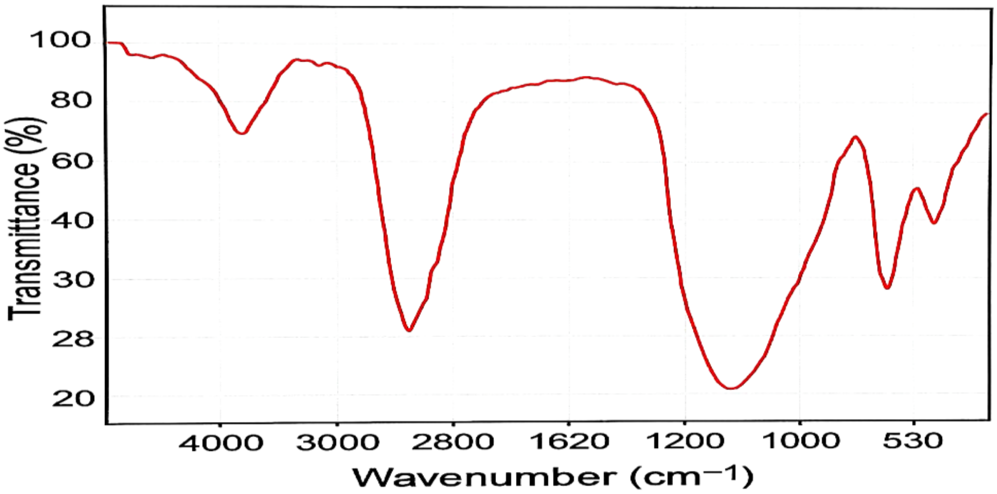

Fig. 5: FTIR analyses of Au2O NPs

7. Antibacterial Activity of Au2O NPs

Using the agar disc diffusion method, the antimicrobial activity of Au2O NPs synthesized from a green teaextract was assessed based on the inhibition zones against a variety of organisms, including S. aureus and Streptococcus and E. coli and Klebsiella, at varying concentrations of 25, 50, and 75%. The findings verify that the various Au2O NP concentrations were successful in preventing the test pathogen from growing, as indicated by (Figure 5 and Table2). It notes that the control well by green tearecorded an effectiveness of up to 10 mm, which indicates the possibility of using extracts against bacterial inflammation and increasing their effect in the presence of nanoparticles. The highest inhibition area for gold oxide prepared usinggreen tea was recorded at a concentration of 75% was17 mm for negative bacteria (Klebsiella Sp.). Because Au2O NPs emit reactive oxygen species (ROS) from their surface, including hydroxyl radicals (OH-), peroxide (O22−), and hydrogen peroxide (H2O2) [15], they have potent antibacterial effects.Furthermore, Au ions inhibit the growth of microbes by reacting with some of the recognized energy groups of proteins, nucleic acids, and biological enzymes [16]

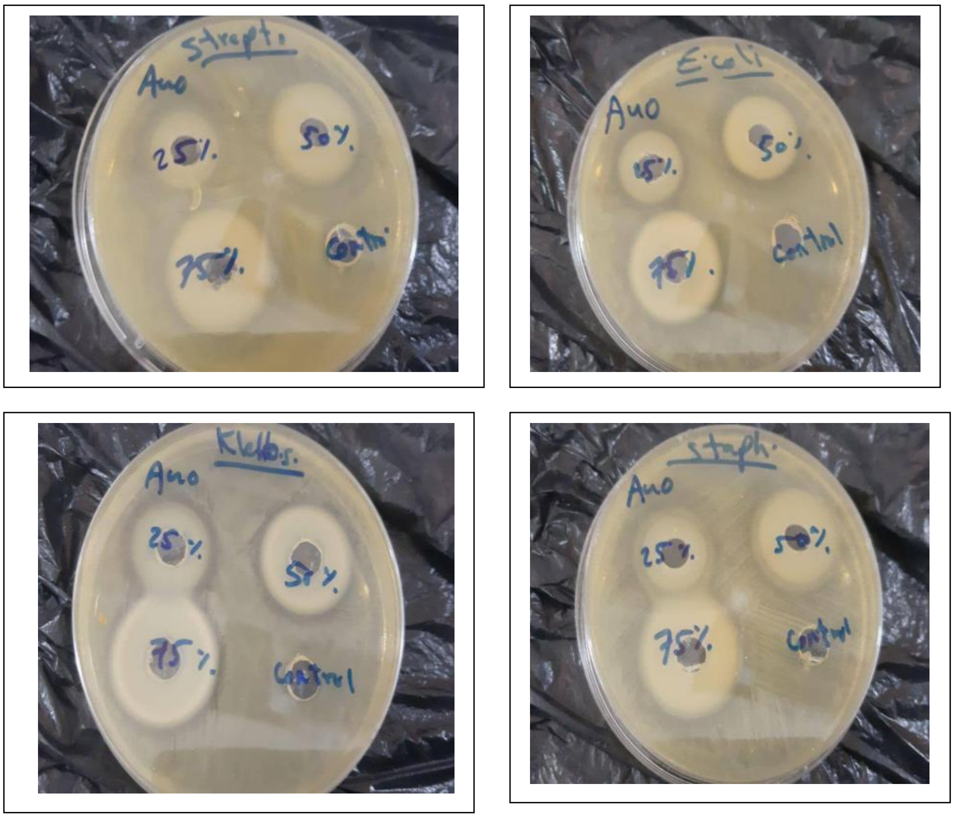

Figure 6: Inhibitory Zones at different concentrations (25,50 and 75%) of Au2O that preparedby green tea

Au2O	E.coli	Klebsiella	Staphylococcus	Streptococcus
control	10	10	10	10
25%	10	15	11	11
50%	12	14	11	12
75%	13	17	11	13

Table 2: Summary of the IZ values at different concentrations (25,50,75 %) obtained for Au2O

8. Conclusion

This study successfully demonstrated the green synthesis ofgold oxide nanoparticles using green tea. The synthesized Au2O NPs exhibited strong antibacterial activity against both Gram-positive andGram-negative bacteria, including drug-resistant strains such as E. coli, Klebsiella pneumoniae, Staphylococcusaureus, and Streptococcus pneumoniae. The nanoparticles were characterized using XRD, FTIR, SEM, and UV-Visspectroscopy, confirming their structural and optical properties. The findings suggest that Au2O NPs synthesizedvia green methods have significant potential for use in medical applications, particularly as antimicrobial agents.Future research must focus on optimizing synthesis conditions, evaluating long-term toxicity, and exploringapplications in drug delivery systems.

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