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Comparison between Green and Chemical Synthesis of Silver Nanoparticles: Characterization and Antibacterial Activit

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Abstract
Using chemical reduction and green technology, two different approaches are used in the current work to synthesize silver nanoparticles. Pomegranate peel extract has been utilized in green technology applications. Furthermore, In the chemical approach, polyvinylpyrrolidine and ascorbic acid were utilized as reducing agents, and the optical, structural, and antibacterial characteristics of the two versions were investigated. In comparison to the chemical reduction variant (30.38 nm), the particle sizes in the green technique (19.5 nm) were smaller. Comparing green silver nanoparticles to chemically synthesized silver nanoparticles, SEM pictures showed that the former had formed a distinct crystalline shape and were evenly distributed on the surface. Granules constituted the shape of the particles. Additionally, it spreads topically. Whereas the greenly synthesized variant's absorption band was at 280 nm, the chemically synthesized variant's absorption band was at 300 nm. It was demonstrated by spectroscopic data of green silver nanoparticles that they have the capacity to produce and stabilize silver nanoparticles. Chemically produced green silver nanoparticles were also exposed to FTIR analysis to identify active functional groups. Silver particles can also be stabilized by chemically produced silver nanoparticles. To assess the antibacterial activity, the nanoparticle agar diffusion method was employed. The bacteria detected in the medium were Staphylococcus aureus and Escherichia coli. In the green form, the bacterial growth inhibition zone was larger and was produced with varying concentrations of 25 ml, 50 ml, 75 ml, and 100 ml, or 13 ml, 10 ml, 9 ml, and 8 ml for Staphylococcus aureus and 15 ml, 12 ml, 10 ml, and 7 ml for E. coli, respectively. Green-produced transcripts exhibited higher antibacterial responses, which were likely caused by the faster rate of nanoparticle stabilization mechanism by organic compounds found in pomegranate fruit peel extract.

Keywords: Nanoparticles, Green Method, Chemical Method, Antibacterial Activity, silver Nanoparticles

INTRODUCTION

Civilization has been gradually shifting towards more environmentally friendly and sustainable methods in all areas of growth during the 20th century, sometimes known as the post-industrial era (Venhoeven, Bolderdijk, & Steg, 2016). Searching for new, more environmentally friendly and sustainable ways to do the things we do every day. Difficulties that require immediate attention include resource depletion, climate and ecosystem changes, insufficient access to drinking water, poor air quality, and other major problems (Ibrahim, Abdelghani, Anwagy, & Rizkallah, 2024; Venhoeven et al., 2016).Consumption is particularly high in the construction industry, where the life cycles of building materials consume a large amount of energy (Küünal, Kutti, Rauwel, Guha, et al., 2016; Küünal, Kutti, Rauwel, Wragg, et al., 2016).

The years have seen a shift in focus towards green and smart housing. Use natural, affordable and environmentally friendly building materials The basic concept of green housing, and the choice of environmentally friendly options depends largely on the quality of the Indoor climate. Research organizations have studied nanomaterials in great detail over the past 20 years. Providing special qualities and methods to make our daily lives better (Huang, Liu, & Wang, 2020; Jadoun, Verma, & Arif, 2020). Metal nanoparticles are very promising in creating new antibacterial agents (Rai, Ingle, Birla, Yadav, & Santos, 2016). Synthesis techniques, which are the traditional methods used to create metallic silver nanoparticles, are usually uneconomical. In certain situations, they also require harmful reagents, along with specialized tools and knowledge. In addition, many of the synthesis procedures are typically energy-intensive and lead to the production of toxic byproducts (Küünal, Rauwel, & Rauwel, 2018). Thus, It is necessary to create technologies that are economical and environmentally appropriate, and biosynthetic technologies appear to offer the greatest promise in this regard (Rauwel, Küünal, Ferdov, & Rauwel, 2015).

Because they offer straightforward methods and a variety of plant material options. Nanomaterials are materials with length scales of 1–100 nm in at least one dimension. The synthesis of nanoparticles as an emerging feature of the convergence of nanotechnology and biotechnology has attracted increasing interest due to a growing desire to be environmentally benign. Nanoparticles are particularly promising for development because they exhibit antibacterial capabilities due to their enormous surface area and volume ratio. The current topic has become under study due to the Increasing resistance of microbes to metal ions and the emergence of resistant strains (Fayaz et al., 2010). For these reasons, silver has long been known to be harmful to 116 different microorganisms (Liau, Read, Pugh, Furr, & Russell, 1997) and is widely used in bactericidal applications (Gupta & Silver, 1998; Nomiya et al., 2004). The bactericidal effect of silver Ions on microorganisms is well known. Their derivatives are commercially exploited as antibacterial agents. Understanding of the bactericidal mechanism is still limited. A strong interaction with the thiol groups of essential enzymes, leading to their inactivation has been proposed (Gupta & Silver, 1998). Based on experimental results, DNA replication is inhibited once bacteria are exposed to silver ions Studies conducted by (Singh, Singh, Prasad, & Gambhir, 2008). demonstrated the presence of small electron-dense granules generated from sulfur and silver, along with structural changes in the cell membrane. Compared to both bulk materials and ions, metal particles with sizes in the nanometer range have distinct physical properties.

Their architecture with highly active facets makes them display exceptional features such as enhanced catalytic activity (Singh et al., 2008). Thanks to their ability to reduce metal ions, microorganisms including fungi and bacteria are now an important part of the toxic metal remediation process (Kalishwaralal, Deepak, Ramkumarpandian, Nellaiah, & Sangiliyandi, 2008).

MATERIALS AND METHODS

Green Method for Preparing Silver Nanoparticles

The type of plant used in this study, which is pomegranate fruit, has been identified, and the peels will be used In this experiment. And cover the AGNPs so that they are more beneficial to humanity. The pomegranate peels were extracted with a solvent, which is distilled water. To determine the best nano-result, the pomegranate peels were air-dried for two weeks and then crushed using a mortar and pestle. 8 g of powder was weighed using a weighing scale and placed in a 250 ml beaker, and 200 ml of solvent (distilled water) was added to the beaker. The mixture was heated for 30 min using a water bath and then filtered through filter paper and then stored in the refrigerator for further use. An aqueous solution of silver nitrate was prepared to synthesize AgNPs. 50 ml of pomegranate extract solution was added to 5 ml of silver nitrate with stirring to reduce the Ag ions to the collected silver groups and then the solution was left for 24 hours until sedimentation to obtain silver nanoparticles.

Figure: (1). Green Silver Nanoparticles

Chemical Method for Preparing Silver Nanoparticles

First, a silver nitrate solution was prepared by adding 4g of $AgNO3$ to 40ml of distilled water and then 20ml of ascorbic acid, solution (A), was added. A PVP solution was prepared by dissolving PVP and glucose in 60 ml of distilled water together, yielding solution (B). Solution B is then heated to a temperature of 60°C by a magnetic stirrer. After stabilizing the temperature for (15 minutes), solution (A) Is added to (B) dropwise. Then the mixed solution was stirred for (10 – 15 minutes) and a brown powder was formed. Then it was dried for 30 minutes at 100 degrees Celsius. Finally, 50 ml of sodium hydroxide (NaOH) was gradually added to the solution until the pH turned to 11.

Figure: (2). Chemically Manufactured Nanoparticles Silver

Antimicrobial Action

Bacterial cultures: nutrient medium agar farms were used to grow bacteria. 850 milliliters of sterilized distilled water were used to dissolve 14 grams of powder to create the medium. After 15 minutes of sterilization at 121 °C to disinfect the medium, bacteria were developed and incubated for 24 hours in the incubation at 37 ° C. Antibacterial Assay: Green and Chemical Synthesis and Antibacterial Activity Using the Agar Disc Spreading Method 72 hours in solid cultural media.

RESULT AND DISCUSSION

Physical properties

Table:(1). Some physical properties of green and chemical nanoparticles

Solubility in DMSO	Solubility in ethanol	Solubility in water	Color and texture	Average particle size	Size range	Boiling point	Melting point	Nanoparticles	Solubility in HNO3
Highly soluble	Good solvent	Melt with vigorous stirring	Completely soluble	Brown	<100	100_80	2162	961.78	Green silver nanoparticles
Highly soluble	Good solvent	Melt	Completely soluble	Black	<100	80_100	2162	961.78	Chemical silver nanoparticles

Scanning Electron Microscopy

The shape of the particles was confirmed by SEM examination. With a working distance (D) of 10.6 mm and a high voltage of 20.0 kV, they were performed at a scale of 200 μm. We show that the silver nanoparticles are well dispersed and have a crystalline morphology, according to the SEM data in Figure 1, while the chemically synthesized silver nanoparticles were synthesized on the 500 μm scale at a high voltage of 20.0 kV and a working distance (D) of 10.1 mm. In this result, the particles are In the form of small grains that are well dispersed, and the aggregation of particles can be seen according to the SEM data in figure 3.

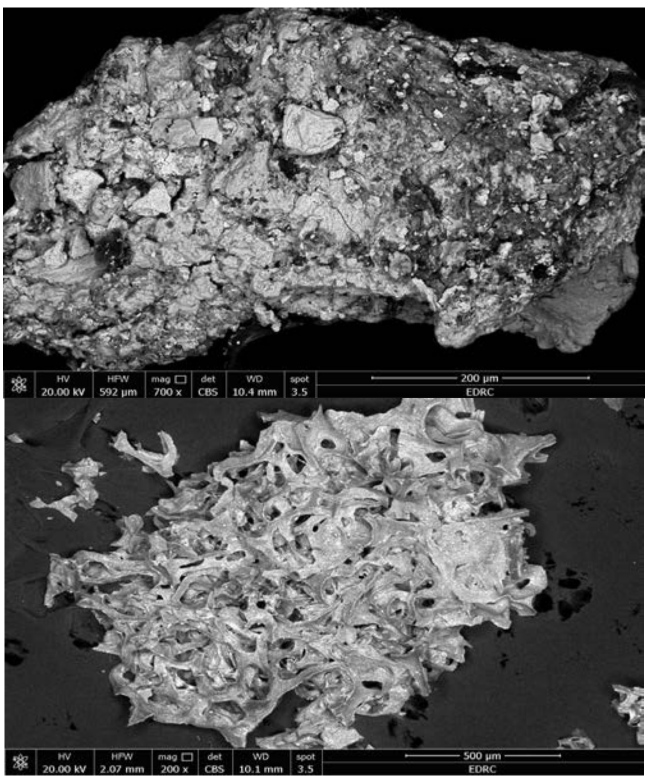

Figure: (3). SEM Micrograph Green Silver Nanoparticles and Chemically Synthesized Silver Nanoparticles

Ultra Violet-Visible Spectroscopy

In the case of the green synthesis method, 30 ml of sample is taken and diluted in 5 ml of distilled water. After half an hour, spectroscopic analysis of green silver nanoparticles was performed and Figure 4 shows the absorption peak at 280 nm and absorbance 1.5. The chemical reduction of silver ions was also monitored in the same way as the first sample dilution. UV spectroscopy was performed as shown in Figure 5 and the absorbance peak was 300 nm and absorbance was 0.4, We note that as the wavelength increases, the absorption intensity decreases, which indicates that the formation did not occur at a large wavelength, so the best formation is for green silver nanoparticles

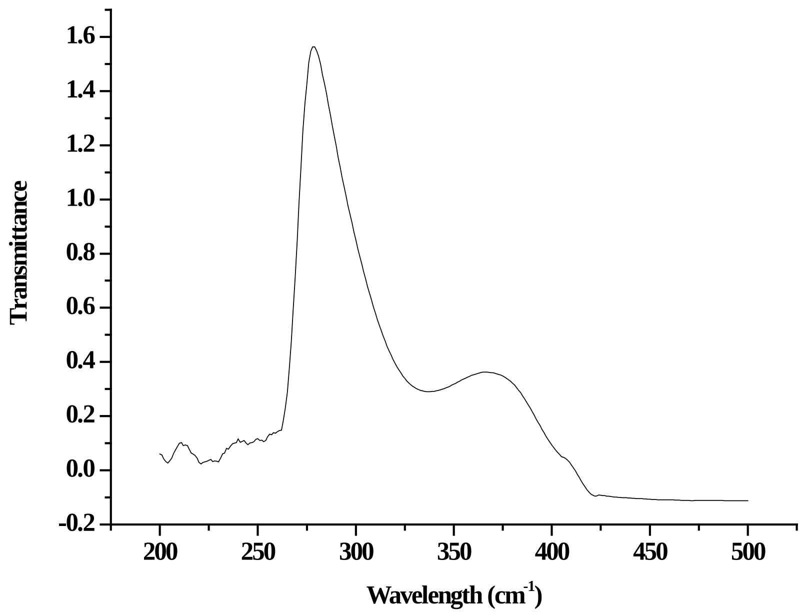

Figure: (4). UV_VIS Spectroscopy of Green Silver Nanoparticles

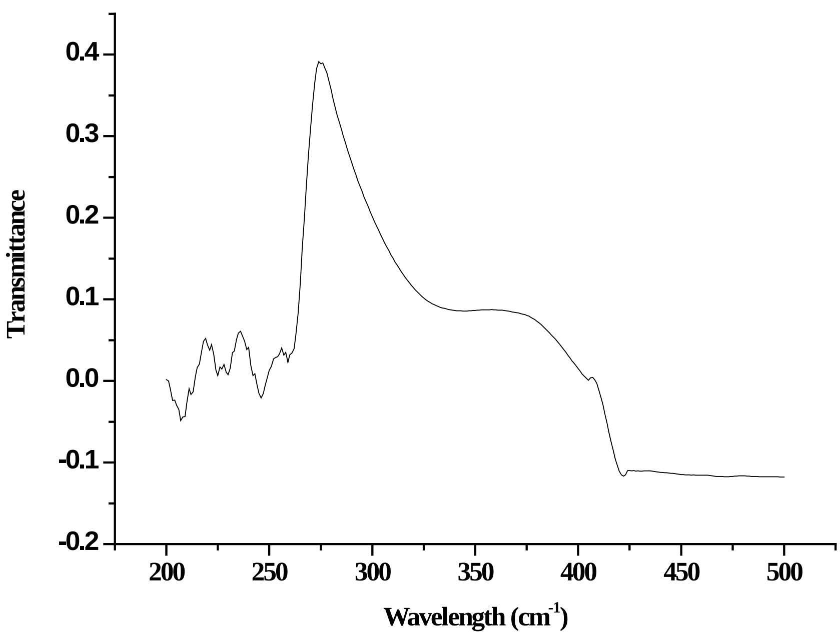

Figure: (5). UV_VIS Spectroscopy of Chemical Silver Nanoparticles

X-Ray Diffraction Analysis

Figure 6 displays the XRD patterns of silver nanoparticles made from pomegranate peel extract. higher proportion of crystalline phases is indicated by the greener peak value displayed by the green nanotube particles. On the contrary, the Debbie-Scherer equation was used to ascertain the crystal size.

$$\text{Particle Size } (D) = K\lambda / (\beta \cos \theta)$$

In this case, μ is the radiation wavelength, θ is the Bragg angle, and K is the dimensionless shape factor 0.94 β represents the full width of the corresponding peak at half maximum as well. D Is essentially the fundamental size of the ordered domains, which is thought to be equivalent to the particle size only relevant to particles smaller than 100. The particle size of green silver nanoparticles can be calculated using the values in the diffraction pattern as follows.

The size of the green nanoparticles produced by the X-ray diffraction pattern was determined:

$$D=K\lambda/(\beta \cos \theta)$$
$$D1=(0.94\times1.54)/(0.184 \cos 30.09)$$
$$D=31.12\text{nm}$$
$$D2=(0.94\times1.54)/(0.231 \cos 68.43)$$
$$D=7.88\text{nm}$$
$$\text{Average crystallite size}= 31.12+7.88/2$$
$$ACS=19.5\text{nm}$$

The size of the green silver nanoparticles ranges between 31.12nm and 7.88nm, so the average crystallite size is 19.5nm.

By the values in the X-ray diffraction pattern of chemically manufactured nanoparticles we can calculate it as follows

$$D=K\lambda/(\beta \cos \theta)$$
$$D1=(0.94\times1.54)/(0.1332 \cos 20.22)$$
$$D=53.20\text{nm}$$
$$D2=(0.94\times1.54)/(0.2008 \cos 19.23)$$
$$D=7.56\text{nm}$$
$$\text{Average crystallite size}=53.20+7.56/2 \ ACS=30.38$$
$$ACS=30.38$$

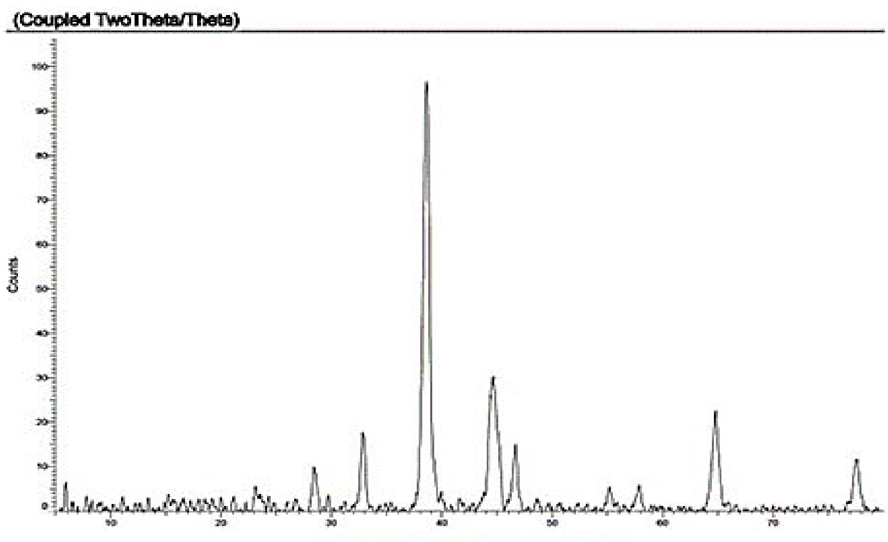

Figure: (6). XRD Diffraction Pattern for Green Silver Nanoparticles

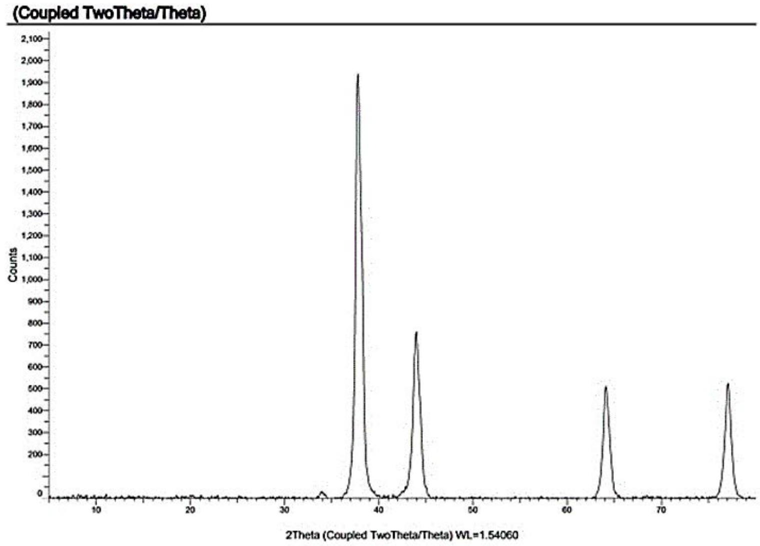

Figure: (7). XRD Diffraction Pattern for Chemically Composite Nano Silver Particle

FTIR Spectroscopy

In order to Identify active functional groups, FTIR is a valuable approach. Figure 8 shows the FTIR spectra of green silver nanoparticles and consists of several bands measured at 2948 cm, 2183.05 cm, 2042.68 cm, 1916.22 cm, 1595 cm, 1392 cm, 858.63 cm, 677.48 cm, 553.09 cm, 498.55 cm. 440.36 cm, Stretching of the hydroxyl molecule is responsible for the band at 29,481 cm, while the aromatic nitro and alkyl vibration modes are responsible for the peak at 1,595.681 cm. The major alcohol in bending or vibration Is responsible for the peak observed at 1392 cm; Either the bands (677.48 cm, 553.09 cm, 498.55 cm, 440.36 cm) are extended for alkyl halides. Evidence suggests that biological molecules may have a role in the stabilization and production of silver nanoparticles: the FTIR spectrum of chemical nanoparticles is shown in Figure 8, which includes multiple bands : 3362.13 cm, 2927.36 cm and 2340.41 cm; 2155.40 cm; 2019 25cm, 1719.95cm, 1643.02cm, 1366.59cm, 1240.31cm; 1021.03 cm; 499.55 cm, the OH (alcohol) or N-H (Ameen) stretches are responsible for the band at 3362.13 cm, while the C-H (alkane) stretch is responsible for the band at 2927.36 cm, while the carbonyl bond group (O=C=O) Is responsible for The range is at 2340.41 cm. The band's N-H (amine) curve appears at 1643.02 cm, while the peak at 1719.95 cm Is the C=O stretch. The secondary alcohol in bending or vibration is responsible for the peak at 1366.59 cm. Based on these facts, we may conclude that chemically synthesized nanoparticles can also contribute to the synthesis and stabilization of nanoparticles.

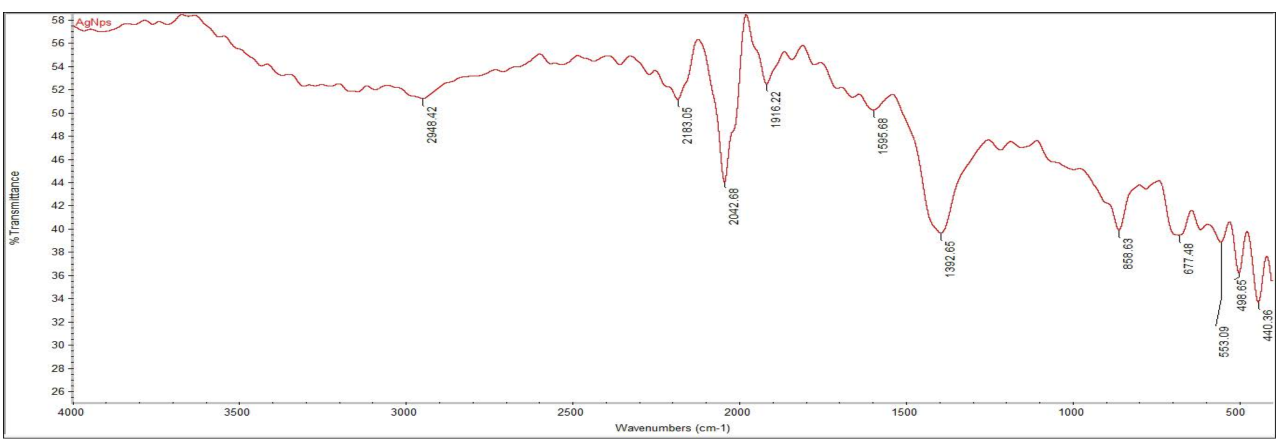

Figure: (8). FTIR Spectra of Green Silver Nanoparticles

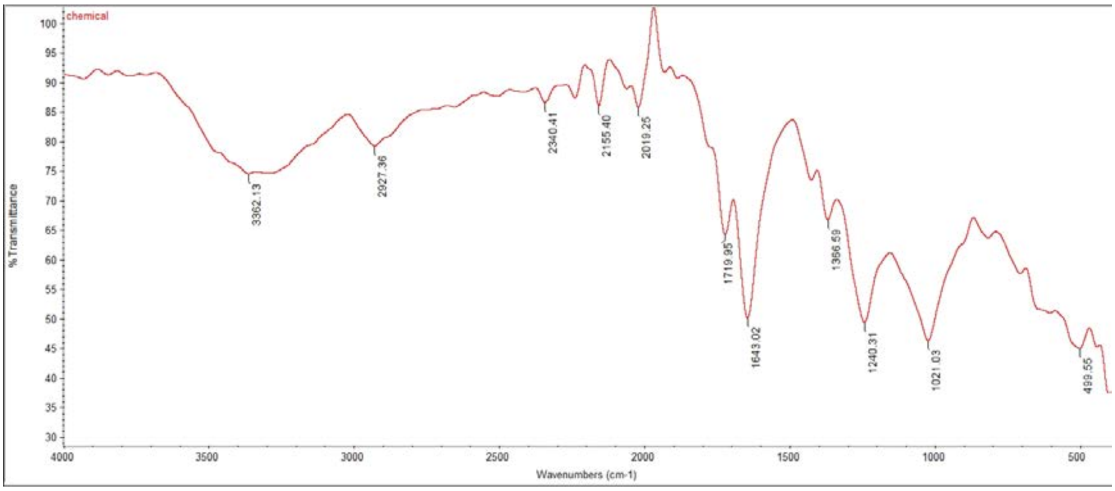

Figure: (9). FTIR Spectra of chemical silver nanoparticles

Antibacterial activity

The antibacterial activity was tested against two distinct strains of bacteria. Green and chemical silver nanoparticles have antibacterial properties against both Gram-positive (Staphylococcus aureus) and Gram-negative (Escherichia coli) pathogens The products were employed in solution form at doses of 25, 50, 75, and 100 mg using the agar diffusion method. After applying all concentrations to the surface of the culture dishes, they were incubated for an entire day at 37°C with the lid on. Following the identification of the compounds' inhibitory effects, it was discovered that the domains of bacterial growth inhibition generated by chemical and green silver nanoparticles were distinct from one another. The ability of nanoparticles to inhibit bacteria is a size-dependent characteristic that gets better as the particle size gets smaller; yet, compared to chemical silver nanoparticles, green silver nanoparticles exhibit a larger zone of inhibition .and Tables 2 and 3 contain tabular data for the Inhibition zone measurements. Because they have larger surface areas and smaller particle sizes than chemical silver nanoparticles, green silver nanoparticles have greater antibacterial potential.

Table:(1). Antibacterial measurements of green nanoparticles

Sample	Bacteria	Weight of the sample	Bacteria type	Zone inhibition
Green Silver Nanoparticles	Staphylococcus Aureus	25	Gram positive	13
		50		10
		75		9
		100		8
	Escherichia Coli	25	Gram negative	15
		50		12
		75		10
		100		7

Table:(3). Antibacterial measurements of chemical nanoparticles

Sample	Bacteria	Weight of the sample	Bacteria type	Zone inhibition
		25		10
Green Silver Nanoparticles	Staphylococcus Aureus	50	Gram positive	9
		75		9
		100		6
		25		12
	Escherichia Coli	50	Gram negative	10
		75		8
		100		6

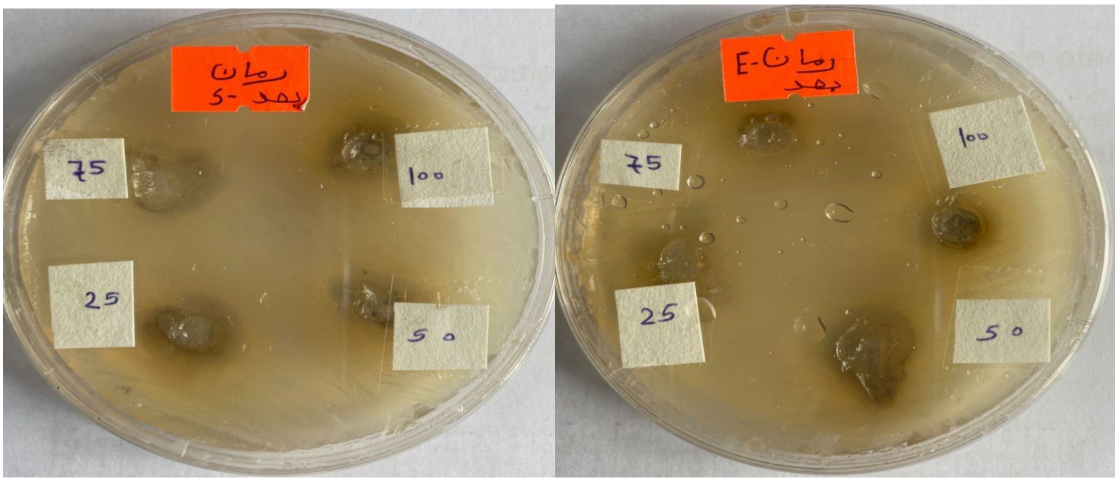

Figure: (10). The antibacterial effect of green nanoparticles with four different concentrations on Escherichia Coli and Staphylococcus aureus

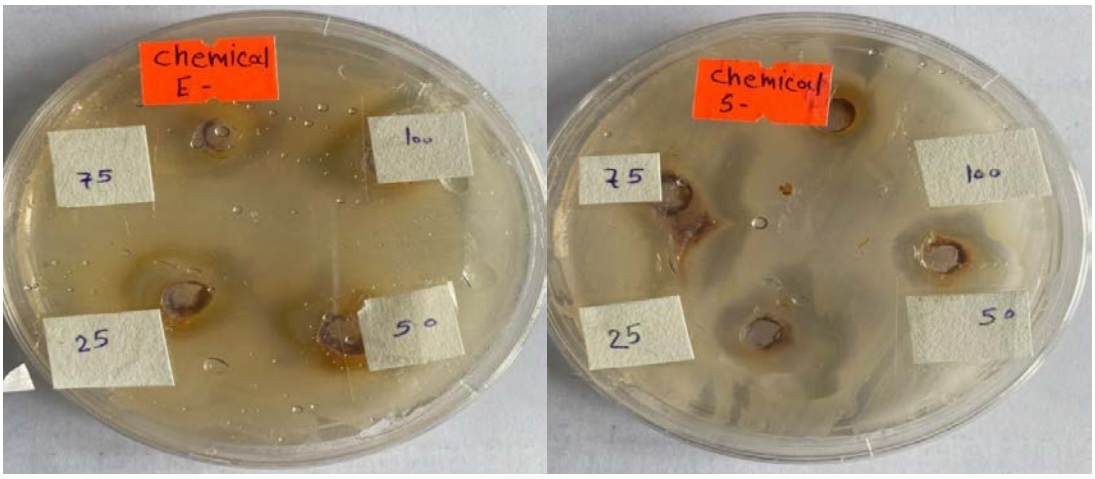

Figure: (11). The antibacterial effect of chemical nanoparticles with four different concentrations on Escherichia Coli and Staphylococcus aureus

CONCLUSION

In this study, Agno3 NPs synthesized by green and chemical synthesis methods were characterized by different techniques to calculate crystallite size, particle size, morphology, spectrophotometry, and antibacterial activity. Different concentrations of silver nanoparticles were studied to inhibit the bacterial activity of two types of bacteria. It was found that green silver nanoparticles were inhibitory to bacterial growth. The average size of the green silver nanoparticles was 19.5 nm, smaller than the chemical silver nanoparticles (30.38 nm), and their optical band gaps were identical. Approximately, spectrophotometry of green silver nanoparticles and chemically synthesized silver nanoparticles shows through spectroscopic data that they stabilize and synthesize silver nanoparticles. Accordingly, green synthesis is more successful, safer and less expensive than chemical synthesis.

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manuscript.

Author contributions: Dalal M Ibrahim and Hamad M Idris designed and arranged the structure of the article; Dalal M Ibrahim and Hind M Mohammed performed the experiments; Dalal M Ibrahim, Hamad M Idris, and Hind M Mohammed analyzed the previous work in this field; and Dalal M Ibrahim and Hind M Mohammed wrote the paper. All authors have read and agreed to the published version of the manuscript.

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