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Photo-Induced Synthesis Of Silver Nanoparticles Using, Syzygium Fruit Peels Extract Characterization, And Antibacterial Activity Studies.

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Abstract: -
In the rapidly developing subject of nanotechnology, nanomaterials are crucial. In this study, silver nitrate (AgNO3) and Syzygium fruit peelings extract—which may function as a capping/stabilizing agent as well as a reducing agent—were used to create silver nanoparticles (AgNPs) via photo-induced reduction green synthesis. It is an easy, inexpensive, and environmentally friendly method that does not require an external stabilizing ingredient. Powder X-ray diffraction (XRD), Transmission Electron Microscopy (TEM), FT-IR, UV-Vis spectroscopy, and Scanning Electron Microscopy–Energy Dispersive X-ray Analysis (SEM-EDX) were used to characterize the produced particles. Using the agar well diffusion technique, the antibacterial activity of the produced AgNPs was assessed against both gram positive and gram negative microorganisms.
Keywords: *Silver nanoparticles, sygygium fruit peels extract, photo-induced reduction and antibacterial activity.*

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I. Introductions

Because of their distinctive SPR (surface plasmon resonance) band in the UV-visible region of electromagnetic radiation, silver nanoparticles (AgNPs) are the most significant metallic nanoparticles [1]. AgNPs have a wide range of applications in different fields, including biological activity, food processing, and sensor technology [2]. The size, shape, and distribution of the nanoparticles affect the SPR band's wavelength. Additionally, the AgNPs exhibit catalytic and bactericidal properties [2]. AgNPs can be synthesized using a variety of techniques, including chemical reduction, photo-induced reduction, biological, and green processes. Due to its speed, non-toxicity, and environmental friendliness, green synthesis is the most important and widely used technique for creating AgNPs. [3]. Plant extracts are often utilized to reduce metal ions and serve as a capping agent to stabilize metallic nanoparticles [4]. 5. The decrease and stability of silver Nps are caused by the hydroxyl, carboxyl, and amino groups found in the bioactive components of plant materials. [6]. The most difficult aspect of managing systems and processes is figuring out the trace amounts of metal ions in biological systems, the environment, and industrial waste streams. In several biological and environmental processes, the ions Fe^{+3}, Hg^{+2}, Pb^{+2}, and As^{+3} have both beneficial and detrimental effects [8–9].

, Therefore, it is crucial for chemical analysis to detect and identify these ions in the environment and industrial waste water. The extract from Syzygium fruit peelings is utilized as a stabilizing and reducing agent in this green synthesis method to convert the silver unstable (Ag^+) ion into the silver stable atom (Ag^0)[10]. Using the agar well diffusion technique, the antibacterial activity of produced AgNPs is assessed against gram positive (Bacillus subtilis) and gram negative (Proteus vulgarism) microorganisms. Several analytical techniques, including UV-Vis spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction Spectroscopy (XRD), Scanning Electron Microscopic and Energy Dispersive Spectroscopy (SEM-EDX), Transmission Electron Microscopy (TEM), and catalytic activity, are used to thoroughly characterize the optical and physicochemical properties of synthesized nanoparticles [11].

II. Materials And Methods

Materials: - The fruit peelings from Syzygium were gathered at a nearby fruit store. We bought silver nitrate ($AgNO_3$) from Sigma-Aldrich. All of the chemicals and reagents utilized in this investigation are analytical grade and don't require any additional purification. All of the experiment is conducted with Milly Q water.

Preparation of Syzygium peelings extract (SGM):- After being chopped into tiny pieces and dried in a hot air oven, the peelings from Syzygium fruits were crushed into a fine powder and put away [12]. A suitable quantity of Syzygium peelings powder is added to Milly Q water, and the mixture is agitated for two hours at 500 rpm in order to prepare the extract. To get a translucent and clear extract, the solution was further filtered using Whatman filter paper. For later use, this extract is then kept in a refrigerator at 4° C.

Synthesis of silver nanoparticles: - Five milliliters of Sygygium fruit extract were combined with two milliliters of AgNO3 aqueous solution. After stirring, the mixture was exposed to sun light for a photo-induced reduction. The reaction mixture's color gradually changed from pale yellow to brown throughout this process, signifying that AgNO3 was reduced to AgNPs. To verify that AgNPs were forming, the reaction mixtures were examined using UV-Vis spectroscopy. Fe+3 and Hg+2 ions were used to study the production of AgNPs at 0.5 mM concentrations of AgNO3 and Syzygium fruit extract. The pellet and liquid supernatant were separated after the produced AgNPs solution was centrifuged at a high speed (20,000 rpm). Once more, the pellets were distributed in Milly Q water.

Characterization: - A dual beam UV–visible spectrophotometer (Shimadzu-3600 Japan) was used to analyze the Syzygium capped AgNPs solution. An FTIR spectrophotometer (Bruker Optics-TENSOR 27, Germany) was used to record the individual Fourier transform infrared (FTIR) spectra of Syzygium and Syzygium capped AgNPs. The 400–4000 cm-1 wave number range was used for the scan. Syzygium-capped AgNPs were subjected to powder X-ray diffraction (XRD) studies using an X'pert Pro powder X-ray diffractometer.

(PAN analytical BV, Netherlands) running at 40 kV, 30 mA of current, and 0.388 min-1 scan rate. The transmission electron microscope (TEM, model TECHNAI G2 F30 S-TWIN, FEI Company, USA) was used to examine the size distribution and morphology of the Syzygium-capped AgNPs at an accelerating voltage of 200 kV. Casting nanoparticle dispersion onto carbon-coated copper grids and letting them cure at 270C was how SEM analysis was done.

Antibacterial activity test:- The agar well diffusion assay was carried out using the procedure outlined in previous papers [13]. The Mueller Hilton Agar plates were covered with 107 CFU/ml of the target pathogenic bacterium. After creating the agar wells using a sterile and clean borer, 50 µL of the sample was introduced. For 24 hours, the plates were incubated at 370 C. Lastly, the inhibitory zone's diameter (mm) was assessed. Proteus vulgaris and Bacillus subtilis were the pathogens employed in this investigation.

III. Results And Discussion

In the current work, we created the AgNPs by subjecting a combination of silver nitrate and Syzygium fruit peeling extract to sunlight (photo-induced reduction), which may function as both a stabilizing and reducing agent. Nanoparticles may be produced quickly in a matter of minutes using photo-induced reduction as an energy source [14].

UV-visible spectroscopic analysis:-

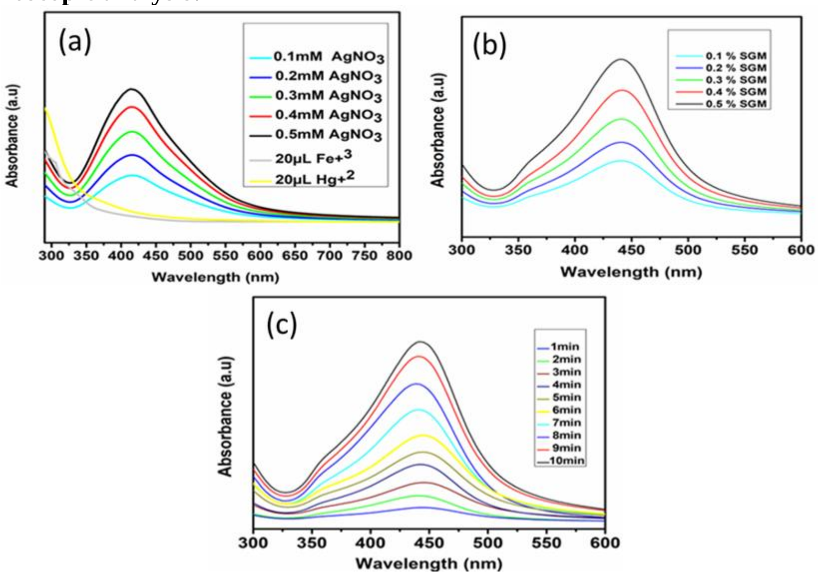

Fig1. UV-Vis spectra of AgNPs synthesized at (a) different concentrations of $AgNO_3$ and 20µl Fe^{+3} and 20µl Hg^{+2},(b) different concentration of SGM extract (c)different time intervel.

One of the most used methods for determining the production of AgNps is UV-visible spectroscopy. In AgNPs' absorption spectra, the Surface Plasman Resonance (SPR) peak at around 420 nm [15] further supports the production of AgNps. After mixing a 0.5% concentration of Syzygium fruit peeling extract with a silver nitrate solution of varying strengths (0.1 to 0.5 mM), the mixture is exposed to sunlight for five minutes (photo-induced reduction) [16]. Since the SPR peak intensity is directly proportional to the concentration of AgNPs in the solution, it grew gradually and reached its maximum value up to 0.5mM concentration of AgNO3 (figure 1a).

The addition of an increasing number of silver ions to the solution, which are easily reduced by the extract's polyphenol compounds to create AgNPs, causes the quantity of AgNPs to grow as the concentration of AgNO3 rises to 0.5 mM [17]. , The lack of polyphenols in the combination may be the reason why the SPR peak intensity and, consequently, the generation of AgNPs did not increase with the further increase in concentration from 0.5 to 0.6 mM of AgNO3.

The mixes are made by combining various extract concentrations (0.1 to 0.5%) with a 0.5 mM AgNO3 concentration. As the extract content rose, so did the SPR peak strength in the UV-Vis spectroscopy of these mixes (figure 1b). This might be because more polyphenol chemicals lead to an increase in AgNP production. However, the SPR peak intensity did not rise with a further increase in extract content from 0.5% to 0.6%; this might be because there were no silver ions present in the combination.

Lastly, by holding all other parameters constant, the photo-induced decrease time is optimized. Increases in SPR peak intensities are also a result of longer irradiation times (figure 1c). The enhanced photo-induced decrease is the cause of this [18]. , AgNP production was not enhanced by further irradiation duration increases. This is because the mixture's polyphenol chemicals and Ag+ ions, which are in charge of the creation and stability of AgNPs, are fully used [19]. , However, when certain concentrated AgNO3 ions are treated with Hg+2 and Fe+3, metal ion detection is shown. This is because the formation of metal complexes with Hg+2 and Fe+3 ions, which are larger than NPs, reduces the peak intensities to ground level.

FT-IR Analysis:-

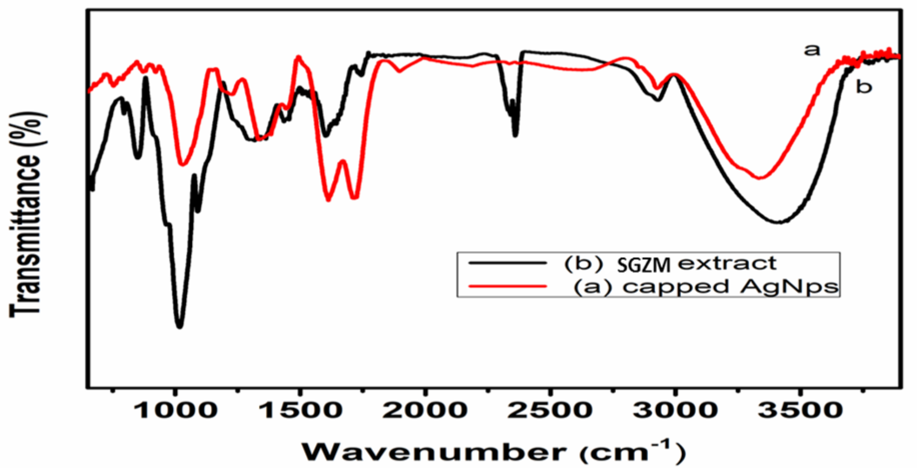

Fig2. FTIR spectra of (a) Sygyzium capped AgNPs and (b) Sygyzium alone.

The interaction between Syzygium's functional groups involved in the reduction of AgNO3 and the capping of subsequently generated AgNPs is demonstrated by the recording of FTIR spectra. The Syzygium capped AgNPs had distinctive stretching frequencies at 3340, 2953, 1716, 1612, 1340, and 1030 cm-1 [21], whereas the Syzygium FTIR spectra displayed stretching vibrations at 3400, 2927, 1737, 1328, and 1020 cm-1 [20]. The large peak at around 3400 cm-1 is associated with polyphenols' O–H stretching vibrations. The strong peak at around 1700 cm-1 can be attributed to carbonyl stretching, whereas the peak at about 2900 cm-1 corresponds to C–H stretching. Moreover, the C–O stretching is responsible for the peaks at about 1050 cm-1. The FTIR spectra of AgNPs capped with Syzygium showed several noteworthy differences from those of Syzygium alone. The hydroxyl groups are likely oxidized to carbonyl groups because, most significantly, the strength of carbonyl stretching rose while the intensity of O-H stretching vibrations dropped. This might be because polyphenol compounds' hydroxyl groups reduce Ag+ ions while phenolic groups oxidize at the same time. Further a clear shift in the peak positions were also observed, which confirms the binding of these functional (reducing) groups with the AgNPs[22].

Powder XRD pattern of Syzygium capped AgNPs:-

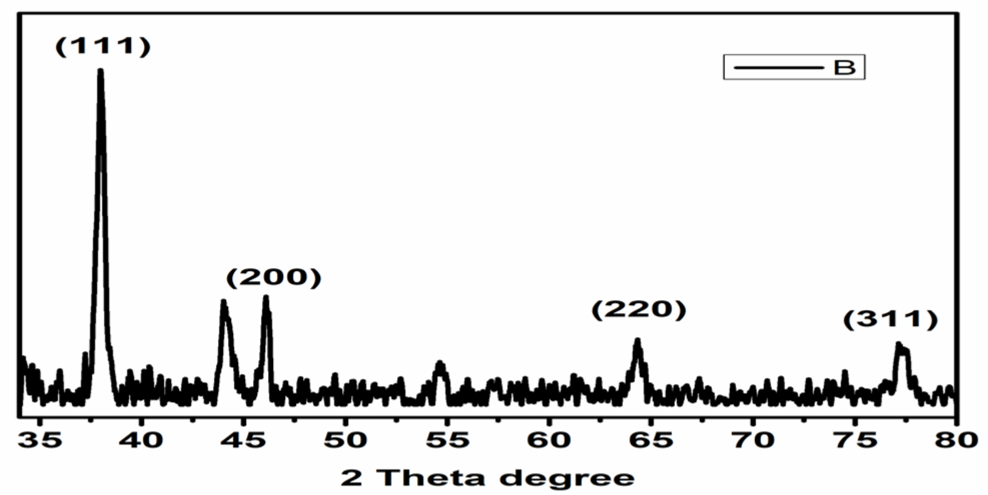

Fig3. Powder XRD pattern of PMG capped AgNPs.

The crystallite and crystalline structure of Syzygium-capped AgNPs were ascertained by XRD examination. Figure 3 illustrates the observation of four distinct peaks at scattering angles (2θ) of 38.35, 44.25, 64.54, and 78.28. The (111), (220), (200), and (311) lattice plane sets are represented by these peaks, respectively. The Face centered cubic (FCC) crystal structure of the Syzygium capped AgNPs is confirmed by these lattice planes. The (111) lattice plane has a high intensity peak, and the widening of these peaks indicates that the produced particles are nanoscale.

SEM-EDX Analysis:-

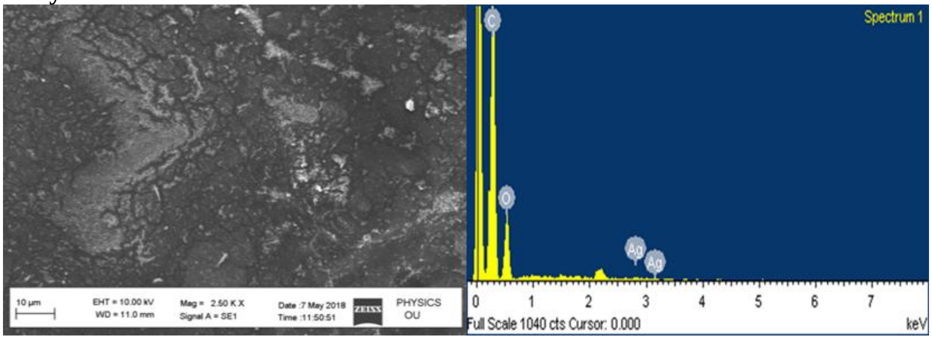

Fig4. (a) SEM image of Sygizium capped AgNPs (b) corresponding EDX spectrum.

Scanning electron microscopy (SEM) was used to investigate the size and morphology of the nanoparticle. AgNPs with a size of around 20 nm and a roughly spherical shape were seen in the SEM picture. Using energy dispersive X-ray analysis (EDX), the purity of capped AgNPs from Syzygium fruit peel extract and the existence of elemental Ag atoms were investigated. The EDX spectrum indicated that Syzygium capped AgNPs had just carbon, oxygen, and silver, as seen in figure 4(b). This suggests that the nanoparticles generated were pure (the C and oxygen come from the extract).

TEM Analysis:-

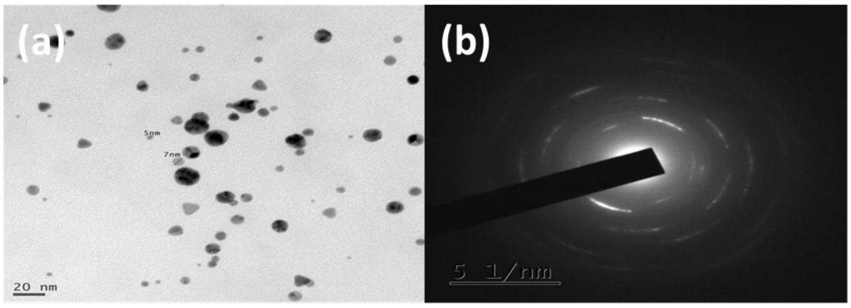

Fig5. (a) TEM image of Sygizium capped AgNPs and (b) corresponding SAED pattern.

The size and form of the AgNPs, which are produced using an extract from Syzygium fruit peelings, were investigated using TEM examination. AgNPs are between 5 and 20 nm in size, according to TEM examination. The produced Syzygium fruit peelings extract-capped AgNPs appear to be spherical in form, with an average size of 10 ± 2 nm, according to TEM examination. The chosen region of the concentric ring electron diffraction pattern showed sporadic brilliant spots, suggesting that these nanoparticles are very crystalline.

APPLICATIONS

Antibacterial Activity :-

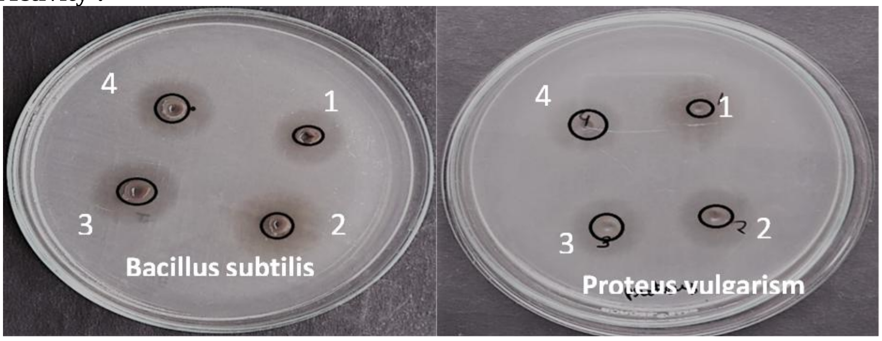

Fig6. Antibacterial activity of PMG capped AgNPs using (a) Bacillus subtilis (b) Proteus vulgarism.

AgNPs capped with Syzygium fruit peeling extract shown strong antibacterial action against both Gram-positive Bacillus and Gram-negative Proteus vulgaris. Both bacteria have grown less as the concentration of AgNPs has risen. AgNPs' zone of inhibition against Bacillus subtitis and Proteus vulgaris bacteria has shrunk. According to these findings, AgNPs made from Syzygium fruit peel extract have more potent antibacterial action against gram-positive bacteria than gram-negative ones.

When using the extract from Syzygium fruit peels alone, a little zone of inhibition was seen. AgNps cause holes in the cell wall, which causes the contents of the cell to flow out and kill the bacterium. The silver nanoparticle has the ability to attach itself to bacterial DNA and prevent transcription of that DNA. AgNPs can reduce medication side effects and cell wall damage because they adhere tightly to the surface of microorganisms, producing obvious damage to the cell wall. According to reports, silver nanoparticles have the ability to pierce and damage bacterial membranes. These findings suggest that the green produced AgNPs significantly inhibited the growth of both Gram-positive Bacillus bacteria and Gram-negative Proteus vulgarism bacteria.

IV. Conclusions

A straightforward, effective, and environmentally benign renewable "green" method for the synthesis of AgNPs has been developed in this work. Without the use of harsh, artificial reducing agents, the synthesis was conducted in an aqueous medium utilizing extract from Syzygium fruit peelings and silver nitrate as a stabilizing and reducing agent. The combination was then subjected to sunlight (a process known as photo-induced reduction). AgNP production was influenced by illumination duration and the quantity of Syzygium fruit peeling extract. The work demonstrates that AgNP generation can be accelerated by photo-induced reduction. The AgNPs generated are effective against both gram positive and gram negative bacteria, according to antibacterial activity investigations.

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