GREEN SYNTHESIS OF SILVER NANOPARTICLES WITH ITS CHARACTERIZATION USING PLANT LEAF EXTRACTS

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ABSTRACT: Conventional methods for synthesizing metallic nanoparticles typically involve the use of hazardous and flammable chemicals. However, the scientific community is now employing silver nanoparticles (AgNPs) in conjunction with various silver nanoparticle formulations, to combat microbial pollution. Among the most effective approaches for producing AgNPs is the utilization of green synthesis methods. The Green synthesis of nanoparticles is evergreen branch of nanoscience for biomedical application. Low cost of synthesis and non toxicity are main features make it more attractive potential option for biomedical field and elsewhere. In this study, silver nanoparticles (AgNPs) were synthesized utilizing liquid leaf extracts derived from three different herbal species: BR-PA, Lysiloma acapulcensis, and SE-SI. The resulting AgNPs exhibited enhanced antibacterial and antimicrobial activity. The synthesized AgNPs were subjected to visual analysis, evaluation of formation, surface morphology, and characterization of antibacterial properties. The synthesized AgNPs were characterized using various analytical techniques including Ultraviolet-visible (UV-vis) spectroscopy, Transmission Electron Microscopy (TEM), Fourier Transform Infrared (FTIR) spectroscopy, and X-Ray Diffractometry (XRD).
This classification process provided valuable insights into the properties and structure of the developed AgNPs.

KEYWORDS: Silver nanoparticles (AgNPs), Green Synthesis, Brillantaisia patula (BR-PA), Lysiloma acapulcensis and Senna siamea (SE-SI**).**

I. INTRODUCTION

Currently, there is growing need to develop eco-friendly and body benign nanoparticle synthesis processes without use of toxic chemicals in the synthesis protocols to avoid adverse effects in biomedical applications. Obviously, researchers in this field paid their attention towards the use of biological systems for the synthesis of biocompatible metal and semiconductor nanostructures [1]. It is most beneficial as considered with traditional synthesis techniques in form of biosynthesis, biocompatible, minimum production costs and biological reductive chemical environment [2]. The synthetic routes utilize non-toxic solvents, chemical precursors and extra minimizing catalyst. Amino acids, photochemical, polysaccharides, polyphenols and vitamins have also been used in green synthesis of NPs [3]. There is a requirement to enhance improved methods/performances using green nanotechnology to enhance capacity of available drugs and antiviral/antimicrobial materials [4].

Presently, there is a significant focus on the advancement of nanotechnologies and nanomaterials in the realm of research. Nanoproducts, characterized by their unique attributes, are being extensively utilized in diverse domains such as medicine, pharmaceuticals, electronics, optics, and environmental safety [5]. Metallic NPs with antibacterial characteristics exhibit another better path to antibiotics. They influence other bacterial frameworks and give them benefits with most particular action compared to antibiotics. However, the mechanism of action of NPs and the aspects affecting the antibacterial impacts are didn't understand properly [6]. In addition of biological polymers enhances the antibacterial outcome of pure NPs and enhances their firmness. Metal nanoparticles (NPs) are exclusively composed of metal precursors. These NPs exhibit unique optoelectrical characteristics attributed to their well-known Localized Surface Plasmon Resonance (LSPR) properties. Alkali and noble metals such as Copper, Silver, and Gold, for instance, possess broad absorption bands within the visible range of the electromagnetic solar spectrum [7]. Dimension and pattern-regulated synthesis of metal NPs are significant in present advanced elements. Because of modern optical characteristics, metal NPs notice the approaches in several analysis fields. Coating of Au NPs is extensively used for sampling of scanning electron microscope (SEM), to increase electronic stream that supports acquiring high standard of that image [8].

Metal NPs have attracted much interest because of their large plane field, high conductivity, improved chemical behavior, and diverse characteristics. Silver NPs have attracted the attention of researchers because of their special characteristics like thermal and large electrical conductivity, Raman scattering, high catalytic activity, chemical stability, and better antimicrobial activity. Silver NPs have important significance as antimicrobial agents differentiated with different noble metals. Hence synthesis of Silver NPs of intended pattern, dimension and antimicrobial activity is explained in this analysis. These unusual characteristics of silver NPs produce specially for cancer therapy by low systemic infectious.

II. LITERATURE SURVEY

The synthesis of nanoparticles (NPs) involves various techniques that can be broadly classified into two main groups: (1) Bottom-up and (2) Top-down approaches. In a study by Khan et al., the sol-gel technique was employed to produce Zinc oxide NPs, which exhibited notable antimicrobial and antifungal properties against Grass bacillus, E. coli, and Candida albicans [9]. In top-down technique, destructive approach is performed. Beginning at a large molecule, it is decayed into little amount and changed into appropriate NPs. One study by Priyadarshana et al., [10] discloses spherical magnetite NP synthesis by natural iron oxide ore with top-down devastating method by particles measurement defers (~20 to ~50 nm) existence of natural oleic acid. Machado et al. [11] studied the possibility of leaf extracts from 26 plants (walnut, vine, tea-green, tea-black, strawberry, raspberry, quince, plum, medlar pomegranate, pine, pear, peach, passion fruit, orange, olive, oak, mulberry, mandarin, lemon, kiwi, eucalyptus, cherry, avocado, apricot, and apple) for synthesis of nanoscale zero-valent iron (NZVI). The resulting NZVI varied in sizes and shapes. The pomegranate and mulberry leaf extracts produced the smallest NZVI (5–10 nm), while only pear tree leaf extracts produced rectangular shaped NZVI.

Richa L Karnani et al. [12] presented a review that described a cheap and environment friendly technique for synthesis of silver nanoparticles by green chemistry approached from different biological sources. The importance of this study includes the precise and specific analysis of silver nanoparticles, biological systems that may support and revolutionize the art of synthesis of nanoparticles. An analysis was conducted by Ren et al. [13], Ultra-fine Copper (II) oxide NP (10 nm) are made by utilizing patented thermal plasma method. This Copper (II) oxide NPs were examined against different bacteria via vitro MBC determination, including by different NPs (i.e., Copper and Silver) engineered is similar situations. In other antimicrobial analysis using qualified microbial techniques, Padmavathy et al. [14] made Zinc Oxide NP with different particles dimensions; little size (12 nanometer) of zinc oxide presented great ability. The authors described higher amount of nanopore substances, formation of active oxygen species and hence it destroy bacteria effectually. It also suggests both abrasiveness and surface oxygen species of zinc oxide NP can develop biocide characteristics of it. Hui Wei et al.[15] described herein the preparation of silver nanoparticles (AgNPs) using nucleobase adenine as protecting agent through the in situ chemical reduction of $AgNO_3$ with $NaBH_4$ in an aqueous medium at room temperature. As-prepared AgNPs were characterized by UV–visible spectra, transmission electron microscopy and x-ray photoelectron spectroscopy. All these data confirmed the formation of AgNPs.

III. GREEN SYNTHESIS OF SILVER NANOPARTICLES

3.1 Materials

AgNPs are great antimicrobial materials implemented in nanomedicine. These influence by microbial cell wall, producing Reactive Oxygen Species (ROS), which finally causes cell death. Hence this analysis concentrates on the green synthesis of AgNPs using liquid abstraction from leaves of Brillantaisia Patula (BR-PA), Lysiloma acapulcensis and Senna siamea (SE-SI). L. acapulcensis is an wide spread perennial tree of south of Mexico, is empirically used in conventional medicine due to abundance and its properties, and cures for organs of respiration, digestive system, urinary and external diseases. The extraction is rich in tannin compounds that allow an approach to antimicrobial characteristics. These types are utilized as antibacterial representatives in Congolese standard medication and till now it didn’t utilized in bio-production of Silver NPs from Ag ion mixtures. The leaves of the plant types were air-dried in the dark at room temperature for one week and then ground produces to a great powder.

3.2 Methods

Preparation of leaf extracts: Powder from leaf (2.5 g) for every herb was vaporized in twenty five milliliter of deionized water for fifteen minutes. The outcome abstraction was later purified (90 mm filter discs) and centrifuged at 4000 rpm for 20 min (MSE Mistral-1000 centrifuge). An acquired abstracts are utilized as green reductants and capping agents for biosynthesis of Silver NPs.

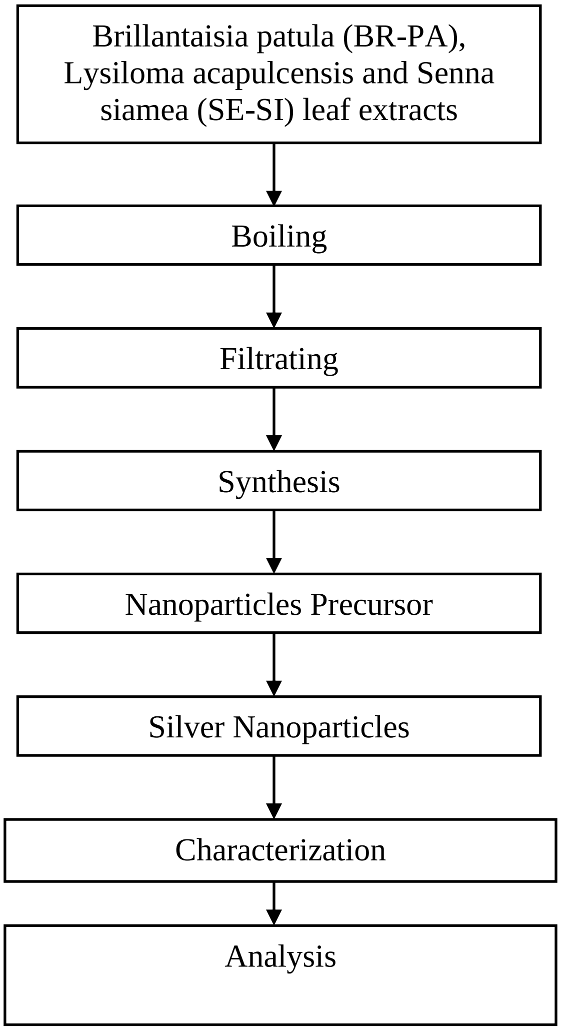

Fig. 1: PROCESS FLOW DIAGRAM OF GREEN SYNTHESIS OF SILVER NPs

AgNPs synthesis: A sustained quantity of 5 mM Silver NO_3 (2 milliliter) was combined by 2, 4 or 8 milliliter, of leaf abstracts. Result quantities were regulated to 10 milliliter by including a required quantity of highly purified water. The final solutions were mixed at 300 rpm (revolution per minute) for 24 hours at 70^{o}C. After cooling reaction medium was centrifuged at 15000 rpm for 15 minutes. The pellets were washed three times by 10 milliliter of highly purified water, freeze-dried, mass and kept at normal temperature and not exposed to sunlight for next classifications. Complete Silver NPs batches were made identical.

3.3 Physicochemical characterizations

UV–Visible spectroscopy: Vision characteristics of biosynthesized NPs were examined using UV–Visible spectroscopy. Later diluting tests by highly purified water, spectra are indicated as operation of wavelength in spectrophotometer 300 to 700 nm operating at 1 nm resolution. Highly purified water was used in empty for UV-Visible tests.

Transmission Electron Microscopy (TEM): Particle morphology and pattern were estimated using TEM. The analysis is diluted tests were settling down as drops onto carbon-coated Cu Transmission Electron Microscopy grids. The extra fluid was soaked by utilizing filter paper and grids are permitted to dry quickly at normal temperature earlier to Particle Visualization. The Software Image J-win32 was utilized to calculate sizes of imagined NPs. The mean sizes are calculated using log-normal fitting, a probability operation generally used for estimate skewed sizes distributions.

Fourier Transform Infrared (FT-IR): The FTIR calculations are consider on Perkin Elmer Spectrum 100 FT-IR using reduced entire deflection technique. These Fourier Transform Infrared spectra are gathered in frequency [4000–650 cm^{-1}] and 8 scans are completed for every test.

X-Ray Diffractometer (XRD): The crystallinity of freeze-dried Silver NP was estimated at normal temperature through XRD utilizing nickel filtered Copper Kα radiations pair at 1.5404 Å, performs 40 kilovolt voltages and 30 milliampere current. The living organisms synthesized NPs are located on glass test tubes and XRD shapes noted in range of 2θ by 10 - 100^0 by scanning rate of 1^0/minute and a slit diameter of 6.0 mm.

3.4 Antimicrobial activity evaluation:

The estimation of antibacterial activity of Silver NPs was examined against three bacterial strains and one yeast (Candida albicans) of research based notice. A traditional broth microdilution technique was utilized to describe Minimal Inhibitory Concentrations (MIC) of Silver NPs i.e., little concentration can totally prevent noticeable development of microorganisms later incubating quickly. Serial two-fold dilutions for Silver NPs leaf extracts as well as Silver NO_3 in Mueller-Hinton Broth are made in unpolluted microscopic hollow tubes utilizing deionized water become solvent. 24 hour-cultures microbial strain is mixed to 0.9 % sodium chloride to reach 0.5 Mc Farland standards (accurately 108 (cfu)/ml). After that, 1 ml of concluded inocula changed 10^6 cfu/ml was increased by similar amount of analysis every example (Silver NPs, extracts and Silver NO3). The acquired solutions were incubated at 37^0C for 24h in environment. Lastly, microtubes are optically tested for turbidity; by cloudiness representing bacterial development was unconstraint with concentration of test examinations included in medium.

IV. RESULTS

Morphology, dimension distribution, substances examination and electron diffraction shapes of AgNPs are classified here.

4.1 UV-Vis spectroscopy:

The achieved synthesis of Silver NPs utilizing examined Congolese plant obtains was confirmed by color change and spectroscopic analysis of the reaction medium and isolated NPs. As shown in Fig. 2, all synthesized AgNPs exhibited distinguishing UV-Vis absorption bands by high absorbance at 434nm, 522nm and 592nm for NPs by Brillantaisia patula, Senna siamea and L. acapulcensis, respectively. The identified UV-Vis are because of Surface plasmon resonance (SPR) extraction and determine existence of Silver NPs, like color modification. Unfortunately, incredible variations are presented in high absorption wavelengths among AgNPs from three herbs.

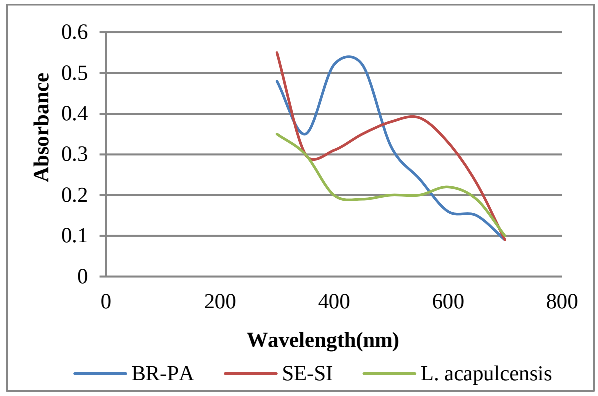

Fig. 2: UV–VIS ABSORPTION SPECTRUM OF GREEN SYNTHESIZED SILVER NPS USING THREE SPECIES EXTRACTS

4.2 Transmission Electron Microscopy (TEM) Analysis:

The morphology and size of biogenic AgNPs were examined by Transmission Electron Microscopy (TEM). Fig. 3 shows representative TEM images of biosynthesized nanomaterials. These example micrographs present the existence of separate NPs with nearly spherical shape and approximately no particle aggregate are parameter to AgNPs. The particle sizes (and size distribution) of synthesized AgNPs were calculated under TEM visualization using ImageJ software, and were found to be about 45 nm (with polydispersity of 32.1%), 115 nm (with polydispersity of 10.8%) and 62 nm (is 26.0%), particles are separately for Brillantaisia patula, Senna siamea and L. acapulcensis. This confirms the nanoparticulate nature of synthesized materials and helps in examination from the UV-Vis spectroscopy, regarding successful generation of colloidal particles from Ag ions in existence of liquid leaf extracts of the Congolese plants.

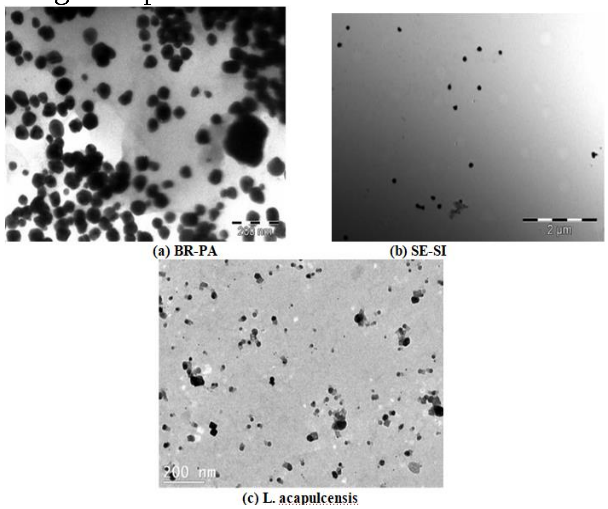

Fig. 3: TEM IMAGES OF GREEN SYNTHESIZED Ag NANOPARTICLES

4.3 FTIR spectroscopic analysis:

This objective for checking the chemical composition of the NPs surface, confirming the generation and capping of AgNPs, and differentiating molecular profiles of three batches of nanomaterials synthesize for various herbs. Fig. 4 shows FTIR spectra of NPs synthesized using Brillantaisia patula, Senna siamea and L. acapulcensis. By most of spectra recorded, many stretching vibration bands relevant to organic functional groups were remarkable noticed. These involve existence of spherical pattern bands at around 3325–3198 cm^{-1}, 2917–2833 cm^{-1}, 1380–1360 cm^{-1}, and 1050–1025 cm^{-1}, which related to vibrations of alcoholic O–H, alkanes C–H, phenolic O–H and C–O stretches, respectively. The FTIR band around 3422 cm^{-1} is assigned to intra molecular H bonds, most probably from water molecules (Fig. 4).

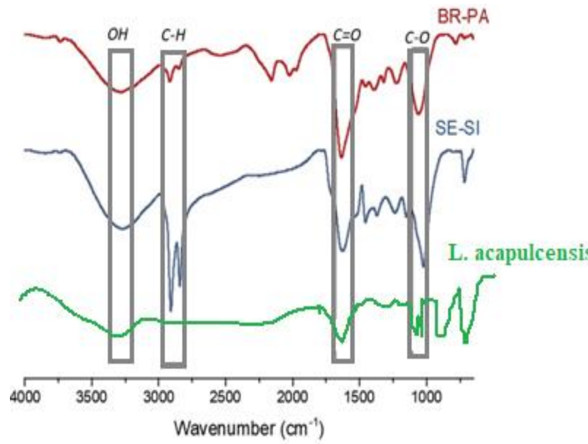

Fig. 4: FTIR SPECTRA OF THE AgNPs USING BR-PA, SE-SI AND L. ACAPULCENSIS

FTIR output lend help to UV-Vis spectroscopy examination concerning molecular interactions among synthesized NPs and phytochemicals that causes to changes in SPR absorption and particle dimensions of Silver NanoParticles by three herbs. Hence, formed Silver NanoParticles batches presents FTIR molecular profiles by various vibration bands; hence it is supposed to sustain various kinds of secondary metabolites on plane as it obtained from various herbs. To accept variations among three batches made, crystallinity of biosynthesized Silver NanoParticles was examined.

4.4 X-ray Difraction (XRD) analysis:

Regarding synthesized nanomaterials, peaks were examined in XRD shapes, thus showing that synthesized nanomaterials didn't consist of Ag metal 100%, but are combined by different elements (phytochemical/capping agents). In fact, XRD profiles determine existence of natural compounds in test, as Braggs reflection seen among 2θ=24.480 and 32.500 is frequently allocated to crystalline and amorphous organic stages. These data are in agreement with FTIR and UV-Visible spectroscopy.

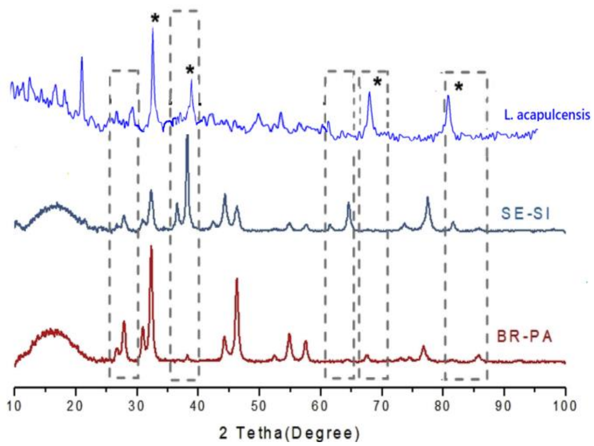

Fig. 5: XRD PATTERN OF Ag NANOPARTICLES

In addition, structure by dashed greys in Figure 5, Silver NanoParticles from three herbs presents characteristic variations in the intensity and location of XRD peaks. This presents the variation in crystallinity of examined elements and plainly describes variation in chemical composition of batches of AgNPs that is because of fact that the extracts provided various capping representatives (being from various herbs).

4.5 Antimicrobial activity evaluation:

The antimicrobial impact of green synthesized Silver NPs was examined on four clinical pathogenic organisms (E. coli, pseudomonas aeruginosa, S. aureus and C. albicans) using Agar well diffusion technique and describing Minimum Bactericidal Concentration (MBC). The liquid abstraction produces a diffuse ring for complete microorganisms. Green synthesized Silver NPs required greater antimicrobial activity than AgNPs. The average of 3 repeated dimensions of inhibition fields consists of Silver NPs suspension is introduced in Table 1.

Table 1: Comparative Analysis of Antimicrobial Activity Between Chemical And Green Synthesized AgNPs

Microorganism	MIC		MBC	
	AgNP Chemical	AgNP Greensynthesis	AgNP Chemical	AgNP Greensynthesis
E. coli	3	0.06	6	0.14
P. aeruginosa	5.5	0.07	>5.5	0.13
S. aureus	3	0.055	6	0.135
C. albicans	6	0.13	>5.5	0.25

In this task, in vitro antimicrobial activity in Silver NPs is synthesized by green technique using BR-PA, SESI and L. acapulcensis extracts. The combination of AgNPs with the three species extracts perform a best next choice against infectious disorders with decreased cytotoxicity. Low chemotherapy impacts are observed for biogenic Silver NPs.

V. CONCLUSION

This study presents a sustainable, cost-effective, simple, and rapid method for synthesizing Silver nanoparticles (AgNPs) using aqueous leaf extracts derived from medicinal herb species commonly employed in traditional medicine, namely BR-PA, Crossopteryx febrifuga, and L. acapulcensis.

Various physicochemical characterization techniques confirmed the successful formation of spherical and crystalline AgNPs. Furthermore, the analysis revealed the involvement of phytochemicals from the leaf extracts as reducing and capping agents in the green synthesis of AgNPs. Therefore, the evaluation of Silver nanoparticles (AgNPs) derived from living organisms reveals enhanced bactericidal properties against common pathogens associated with infectious skin disorders, such as Staphylococcus aureus, E. coli, and Pseudomonas aeruginosa. These biogenic AgNPs exhibit superior efficacy at lower concentrations compared to chemically synthesized Silver NPs. Furthermore, in terms of toxicity, biogenic AgNPs do not significantly affect cell viability in human peripheral blood lymphocytes. This observation suggests that the biomolecules present on the surface of nanoparticles contribute to enhanced biological activity. The study confirms that bio-functionalized Silver nanoparticles (AgNPs), obtained through environmentally friendly synthesis using medicinal herbs, possess the potential to combat microbial skin diseases and antibiotic resistance. These findings underscore the significance of green synthesis of AgNPs from herbs, as it presents a promising avenue for the development of effective treatments for microbial disorders, particularly infectious skin conditions, in the field of medicine.

VI. REFERENCES

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