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REVIEW ON GREEN SYNTHESIS OF SILVER NANO PARTICLES, CHARACTERIZATION AND ENVIRONMENTAL REMEDIATION AND BIOACTIVITIES APPLICATIONS

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Abstract: Silver has long been thought to be a toxic, yet nontoxic, inorganic antibacterial/antifungal metal. Biocidal nanoparticles are the most prevalent form. Silver, specially existed as nanoparticles, offers promise in a varity means of environmental rehabilitation activities by having created environmental degradation. Environmentally friendly tecnique methods are becoming more common in Nanotechnology in terms of fabrications, and the interest for green synthesis methods is expanding, with the aim of treating polluting reaction by-products. These procedures are also cost-effective and have a plentiful supply of raw materials. Researchers looked into its expansion, particularly in terms of synthesis procedures. The production of nanoparticles from silver is currently attracting considerable interest due to its unique properties, architectures, and uses in numerous industries. Alternatively, as a result of additional development, physical, chemical, and other methods for the creation of silver nanoparticles have all been recorded. However, the nanoparticles created using these processes are both expensive and harmful to the environment. Various elements, including as synthesis processes, temperature, dispersing agent, surfactant, and others, all have an impact on the quality and quantity of nanoparticles generated, as well as their qualities, which may lose or gain their primary applications. It's also worth noting that the primary goal for these silver nanoparticles was to synthesis them in a simple, ecologically friendly, and cost-effective method. As a result, this review focuses on the various methods for making green nanoparticles that are both environmentally friendly and simple to make at a low cost. We'll also go over some of the key characteristics that could lead to the newly developed nano particles being effective in a range of applications, such as antibacterial, antifungal, anti-inflammatory, antiviral, cardiac protection, wound dressing, and so on.

Index Terms: Antibacterial activity, Antifungal activity, Anti-inflammatory activity, Antiviral activity, Cardio protection, Wound dressing and Environmental Remediation

I. *INTRODUCTION*

Nanomaterials are thought to be one of the most cutting-edge materials available. They've been termed the "material of the twenty-first century" [1] because of their unique designs and property combinations when compared to traditional materials. They are necessary for a wide range of applications, including human health appliances, industrial fields, pharmaceutical applications, biomedical sectors, engineering, electronics, and environmental research [2]. In the domains of life science and biotechnology, the use of nanoparticles (NPs) to create new types of analytical instruments has recently gotten a lot of attention [3]. Ag-NPs are the most widely used nanomaterials and may be regarded as one of the most important. They've becoming increasingly popular as a consumer product material [4]. Ag-NPs are used in medicine, medical devices, pharmacology, biotechnology, electronics, engineering, energy, magnetic fields, and environmental cleanup [5]. Ag-NPs have gained popularity in a variety of industries, including textiles, food, consumer goods, pharmaceuticals, and others, due to their potent antibacterial action in solution and in components [6]. Silver nanoparticles (Ag-NPs) are commonly employed in environmental cleanup.

Silver has a wide range of biological and chemical applications, notably in the form of nanoparticles (NPs). In nanobiotechnology, environmentally friendly NP synthesis procedures are gaining popularity, and demand for biological synthesis methods is increasing, with the purpose of removing harmful and polluting elements. In the "green Synthesis" process, bacteria, fungi, and algae cultures, plant extracts, and other biomaterials are typically employed. Because of the lengthy procedure of microbial isolation and pure culture control, plant-based green synthesis is a simple, fast, dependable, cost-effective, environmentally sustainable, and one-step technology that has a significant advantage over micro bial synthesis. We used spectroscopy (UV–vis, FTIR), microscopy (TEM, SEM), X-Ray diffraction (XRD), and other particle analytic techniques in this review to discuss the green synthesis and characterization of silver nanoparticles (Ag NPs). This study looks at the potential applications of Ag NPs in a variety of biological and chemical domains, with a focus on environmental remediation and bioactivities.

1.1 What is the purpose of silver nanoparticles? Why are we interested in Ag NPs?

It is one of the first and most evident questions.Compared to other metallic nanoparticles, Ag NP has a number of advantages. Others include a large fraction of Ag2O, despite the fact that many are categorized as "Ag NPs" due to the high relations of surface to bulk Ag atoms. Over the last ten years, Ag NPs have been employed in a wide range of electronic and medical equipment, surgical instruments, bone cements, surgical masks, and other applications [7,8]. In addition, a specified amount of ionic silver is applied to wounds. As a result, Ag NPs are used to cure wounds and burns [9–11]. Because of their wide scattering cross-sections and surface plasmon resonance, Ag NPs are used in molecular labelling [12]. As a result, a wide range of Ag NP applications are becoming more well recognized [13–15].

1.2 Why Environmental remediation applications?

Many researchers has tried to reveal the successful use of Ag NPs as plasmonic sensors for water pollutants like heavy metals and organic compounds, as well as photocatalysts for promoting the oxidative degradation of environmental pollutants like dyes and pesticides, thereby expanding the field of environmental research.Concerns regarding their impact on people and the environment have developed as their use in environmental applications like water treatment has increased. A new eco-design methodology has just been proposed that allows for optimal material performance while providing no risk to natural ecosystems or live things. The potential of Ag NPs for water pollution monitoring and remediation is discussed in this review in order to ensure that they are handled in an environmentally safe (eco safe) way. Because they are highly efficient in pollutants sensing and degradation, their eco-safe application can be realised in many types of fabrications, notably with cellulose, by adopting an eco-design approach. In reality, (Ag NPs)–cellulose hybrids have the added advantage of being simple to create from recycled materials, with low costs and the potential for reuse, as well as being environmentally beneficial if made properly. The use and prospects of these new hybrid AgNP-based materials have been revised, which will surely hasten their environmental application, with significant economic and environmental repercussions.

2.Green Synthesis Methods

2.1 Green Synthesis Using Bacteria

Bacteria have been observed to fabricate inorganic chemicals both inside and outside the cell. As a result, they might be employed as bio factories for the manufacture of gold and silver nanoparticles. Although silver is recognized for its biocidal properties, some bacteria are silver resistant [16] and can gather up to 25% of their dry weight biomass in silver on their cell walls, suggesting that they could be employed in commercial silver recovery from mining sources [17]. As a result, scientists began investigating the use of prokaryotic bacteria as nano factories. For the first noble metal nano particle manufacturing using bacteria, silver resistant bacterial strains Pseudo monasstutzeri AG259 were cultured in high concentrations of silver nitrates. The cells were found to accumulate a significant amount of silver, the majority of which was deposited as 200 nanometer-sized particles [18]. Significant results were obtained when bacteria Proteus mirabilis PTCC 1710 were used to generate silver nanoparticles. Depending on the type of "broth" used during the incubation Bacteria have been found to manufacture inorganic compounds both inside and outside of the cell. As a result, they could be used as biofactories for producing gold and silver nanoparticles. Despite the fact that silver is known for its biocidal qualities, some bacteria are silver resistant [16] and can accumulate up to 25% of their dry weight biomass in silver on their cell walls, implying that they could be used in commercial silver recovery from mining sources [17]. As a result, researchers started looking into using prokaryotic bacteria as nanofactories. Silver resistant bacterial strains Pseudo monasstutzeri AG259 were cultivated in high concentrations of silver nitrates for the first noble metal nano particle synthesis employing bacteria. The cells accumulated a large amount of silver, with the majority of it deposited as 200 nanometer-sized particles [18]. When bacteria Proteus mirabilis PTCC 1710 were employed to make silver nanoparticles, significant results were found. Extracellular or intracellular synthesis can be increased depending on the sort of "broth" utilised during the incubation of bacteria. Bacterial-based green synthesis is adaptable, affordable, and suitable for large-scale production due to this form of selection [19]. It's worth noting that bacteria continued to multiply after the silver nanoparticles were created. However, utilising bacteria as nanofactories has a number of drawbacks, including a sluggish rate of synthesis and a limited range of sizes and forms [20]. Because of this type of selection, bacterial-based green synthesis is versatile.

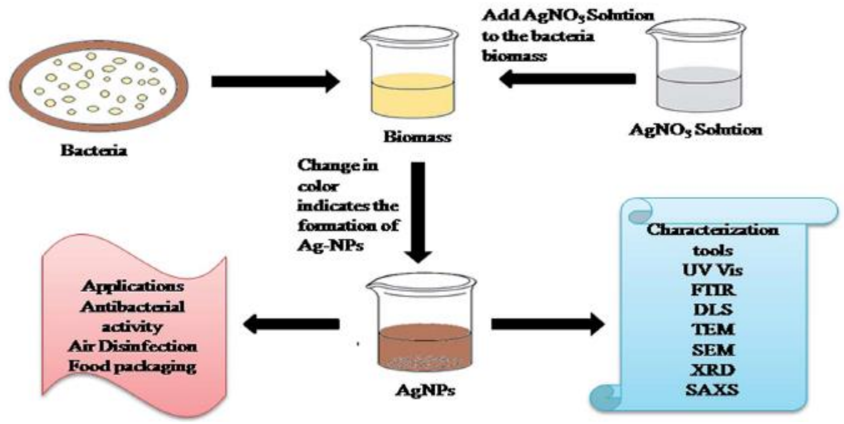

Figure. 2.1 Mechanism for the green synthesis of AgNPs from bacteria.[21]

2.1*Green Synthesis Using Fungi as Medium.*

Fungi, like bacteria, have been studied in the biological creation of metallic nanoparticles due to their tolerance and metal bioaccumulation ability, high binding capacity, and intracellular uptake. Fungi are easier to manage in the laboratory than bacteria. Fungi, on the other hand, produce nanoparticles through the secretion of huge amounts of enzymes that break down silver ions, resulting in the production of metal nanoparticles [22]. The first metal nanoparticles were synthesised utilising fungal-mediated techniques in the early twentieth century, with AgNPs with a diameter of 2512nm generated utilising the fungus Verticillium [23,24]. Pseudomonas stutzeri AG259, a bacteria isolated from silver mines, was previously found to be capable of producing AgNP with a well-defined size and morphology within the bacteria's periplasmic area [18]. With verticillium-based synthesis, the green method is pushed even farther. Ions are decreased and AgNPs are formed when the fungus is exposed to AgNO3 solution. Nanoparticles with a diameter of about 25nm and a spherical shape with strong mono dispersity were discovered. Ag NPs are formed underneath the surface of fungal cells, unlike bacteria [23]. This is in contrast to Klaus et al. (1999), who discovered that bacterial particle morphologies spanned from spherical to triangular to hexagonal. The mechanism of nanoparticle formation was then investigated, with the major hypothesis being that NPs are created on the surface of the mycelia rather than in the solution in the case of fungi-based synthesis. Because of an electrostatic contact between negatively charged carboxylate groups in enzymes in the cell of mycelia,

In the first phase, it was hypothesised that Ag+ ions are adsorbed on the surface of fungal cells by the wall and positively charged Ag ions. Finally, enzymes in the cell wall decrease silver ions, resulting in the creation of silver nuclei [23]. Switching from bacteria to fungi as a source of natural nanofactories has the benefit of simplifying biomass processing and downstream management. Fungi excrete far more proteins than bacteria, boosting the efficiency of this biosynthetic technique; also, fungi might be employed to produce vast amounts of metal nanoparticles. Ahmad et al. published the first investigation on extracellular manufacturing of silver nanoparticles using eukaryotic systems like fungus in 2003. The reduction process is mediated by secreted enzymes, according to the researchers [25]. All fungi-based biosynthesis took happening within cells prior to this research. Extracellular synthesis is favourable because the nanoparticles produced are not attached to the biomass [26, 27], allowing for the biosynthesis of nanomaterials with a wide range of chemical compositions, such as oxides, nitrides, and other materials. Fungi are widely employed in green synthesis due to their environmental friendliness and ease of handling when compared to other types of microbes.

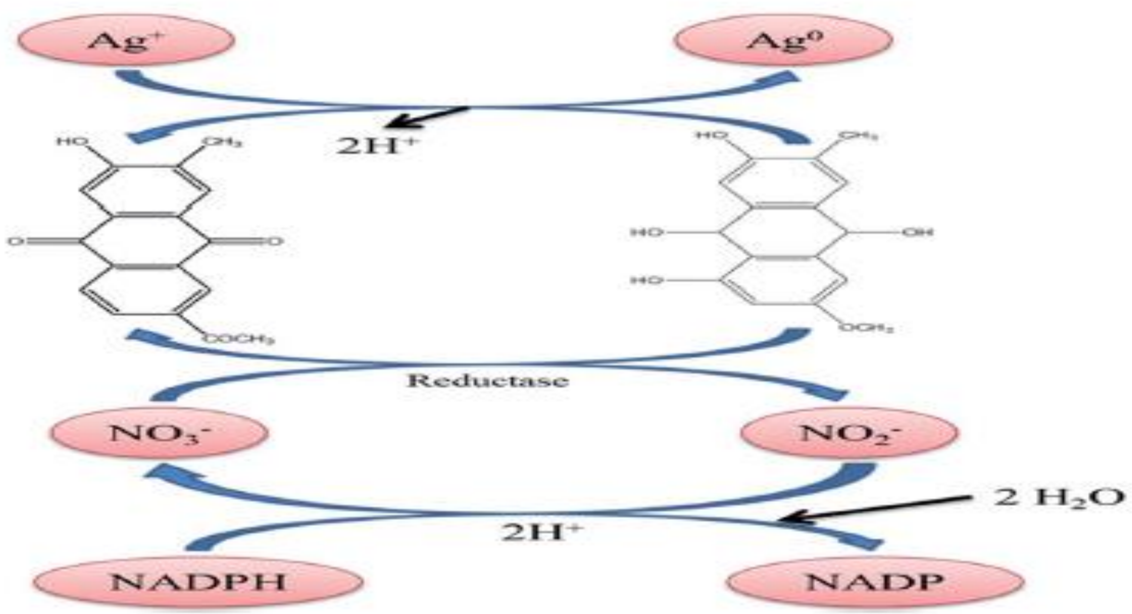

Fig. 2.2 Mechanism for the synthesis of AgNPs using fungi.[21]

2.2*Alga-mediated synthesis of AgNPs*

Algae are a varied collection of aquatic microorganisms that have been exploited to generate large quantities of AgNPs. They are microscopic (picoplankton), macroscopic (macroscopic plankton), and macroscopic (macroscopic plankton) in size (Rhodophyta). The microalgae Chaetoceros calcitrans, C. salina, Isochrysis galbana, and Tetraselmis gracilis were used to make AgNPs. [Section 28] To synthesise AgNPs, Prasad et al. used Cystophora moniliformis sea algae as a reducing and stabilising agent. [30] Micro- and macroalgae utilised to make Ag NPs.

2.4 Green Synthesis Using Plants as Medium.

Plant-based AgNP synthesis is preferred over microorganism-based AgNP synthesis because it is easier to improve, less biohazardous, and does not require cell culture expansion. [30–34] Biomolecules (such as enzymes, alkaloids, polysaccharides, tannins, terpenoids, phenols, and vitamins) can be found in all parts of a plant (leaves, fruits, roots, seeds, and stems) and are beneficial to the environment despite their complex structures. [35] All dangerous compounds such as trisodium citrate and sodium borohydride are replaced with plant extract ($NaBH_4$). The creation of AgNPs, which is stabilised by the flavonoid and terpenoid components of leaf broth, aids in the production of NPs, while the polyol and water-soluble heterocyclic components of leaf broth aid in the reduction of silver ions. For the first time, AgNPs were produced using a plant extract from Salvia spinosa produced in vitro. '[37] Gardea Torres Dey et al. presented the first study on the production of AgNPs by a living plant system, Alfalfa sprouts (2003). Alfalfa roots may take Ag from agar medium and transport it in the same oxidation state to the plant's shoots. In the shoots, these Ag atoms are transformed to AgNPs. Hare Krishna Bar et al. (2009)[38] used Jatropha curcas latex as a reducing and capping agent in their study. AgNP synthesis is necessary. Sithara et al.[39] produced AgNPs from Acalypha hispida leaf extract and utilised them to detect Mn^{2+} ions. [40] Gavhane et al. (2012) used EDX, TEM, and NTA to characterise AgNPs made from a Neem and Triphala extract. The AgNPs were discovered to be spherical and in the size range of 43 nm to 59 nm using TEM and NTA. [41]. In the synthesis of AgNPs, Ahmad and Sharma (2012) used Ananas comosus (pineapple juice) as a stabilising and reducing agent. [42]. Charusheela Ramteke et al. (2012) used the leaf extract of (Tulsi) Ocimum sanctum to make antibacterial AgNPs. (#43) Roy et al. (2014) produced AgNPs with an average diameter of 20 nm using Malus domestica fruit extract as a reducing and capping agent. NP formation was assessed using UV-vis spectroscopy, morphology and phases were studied using TEM and XRD, and biomolecules for NP reduction and stabilisation were identified using FTIR spectroscopy. (44). Velmurugan et al. (2015) synthesised AgNPs from peanut shell extract and compared them to commercial AgNPs in terms of antifungal activity and features. Premium Jose Vazhacharickal et al. (2015) used Curry leaf (Murraya koenigii) as the reducing and capping agent to produce AgNPs with good antibacterial activity. [46] M. Firdaus et al. (2017) synthesised AgNP under sun irradiation using aqueous fruit extract from (Caricapapaya)papaya as the reductant and no other capping agents. UV-vis spectrophotometry and FTIR spectroscopy were used to investigate the AgNPs. AgNPs' high selectivity for the toxic heavy element mercury in aqueous solution led to the creation of a green environmental sensor. [47] Jerushka S. Moodley et al. (2018) investigated the antibacterial activity of synthetic AgNPs created from Moringa oleifera leaf extracts using sunlight as the primary energy source. [48] Yu C. et al. (2019) used Eriobotrya japonica (Thunb) leaf extract to generate AgNPs, which were then used to break down reactive dyes catalytically. a [49] The best prospects for producing AgNPs are angiosperms that look like plants. Ag is made from medicinal herbs like Boerhaaviadiffusa. Tinosporacordifolia, Terminalia chebula, Tinosporacordifolia, Tinosporacordifolia, Tinosporacordifolia, Tinosporacordifolia, [52] aloe vera, [53] Ocimumtenuiforum, [54] Catharanthus roseus Azadirachtaindica, Emblica officinalis, Emblica officinalis, Emblica officinalis, Emblica officinalis, Emblica officinalis, Piper nigrum, for example, is a common spice. Coco is a character in the film Coco (58 points) AgNPs have also been made from plants that produce essential oils (Mentha piperita) and alkaloids (Papaver somniferous). On a few cases, external compounds such as sodium-dodecyl sulphate have been utilised to stabilise AgNPs. [Number 59] Plant extracts all function as reducing and capping agents. Proteins, metabolites, and chlorophyll in plant extracts act as stabilising factors in the formation of AgNPs. The pathway for AgNP production in plants is described. We'll go through more AgNP syntheses, conditions, characterisation, and applications farther down.

3. *Characterizations of AgNPS and analytical techniques*

Characterization of NPs is a crucial part of material science research, and we can't be sure if nanostructures are formed without it. To properly understand the created substance, basic analytical processes such as spectroscopy and microscopy are required. Characterization includes processes including material research such as mechanical, thermal, and density examinations, as well as methods for examining material properties and microscopic structures. Characterization helps in defining material structure and content, as well as determining whether or not a treatment was successful. In this section, we talked about UV–vis spectroscopy, Fourier Transform Infrared (FTIR) spectroscopy, Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), x-ray Diffraction (XRD), and Zeta potential/particle analysis.

Various characterization measures for AgNPs have been published in order to learn more about their essential applications and growth parameters. The TEM and SEM were helpful in elaborating on the overall shape of the particles. To determine the elemental analysis more efficiently, the SEM apparatus is combined with energy dispersive X-ray spectroscopy (EDS). FT-IR, X-ray photoelectron spectroscopy, UV–Vis's spectroscopy, and X-ray diffractometry (XRD) are commonly used to analyses and confirm AgNP production. However, XRD is very useful for evaluating crystallinity, and the Loresta-GP MCP-T610 resistivity metre is used to determine volume resistivity. The UV–Vis result of the generated nanoparticles shows an optical absorption peak because the surface plasmon resonance is easily observed (Chouet al. 2004). In EDS exploration, the AgNPs can be detected by their concentrated peak about 3 keV. Other chemicals with lower concentrations, such as O and C, are related to the reagents used, which are no longer present due to the water solubility factor. The XPS technique is used to determine the elemental composition of AgNP.

3.1 Ultraviolet-Visible spectroscopy (UV–vis)

The most extensively utilized method for detecting extracellular green production of NPs in reacting fluid is UV–vis spectroscopy. In addition to assessing the concentration of an NP suspension, a UV–vis spectroscope can be used to analyse the colour absorption patterns of metallic-NPs (through surface Plasmon resonance), as well as the sorption, diffusion, and release properties of nanostructures.

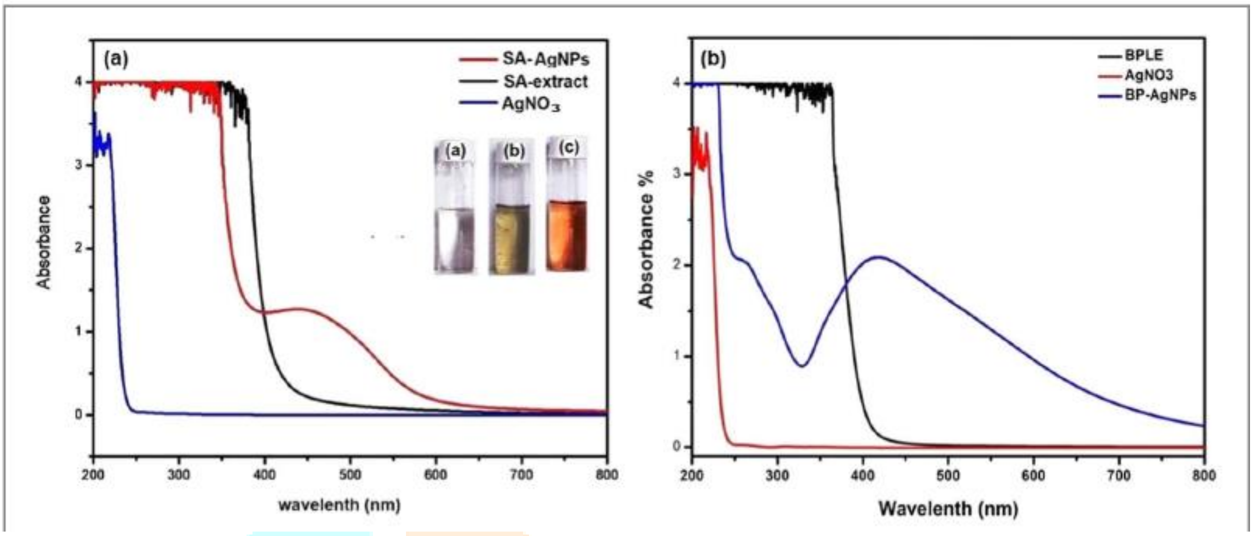

Figure 2.1. UV-visible spectra of(a)SA-Ag NPs and (b) BP Ag NPs (Images are taken from publications [62,63].

3.2 Fourier transform infrared (FTIR)spectroscopy

The emission and absorption of samples such as gas, liquid, or solid produce an infrared spectrum in FT-IR spectroscopy. A specific spectrum of frequencies can be absorbed by each functional group and chemical bond. As a result, the distinct peaks for each functional group or component of the molecule may be seen.

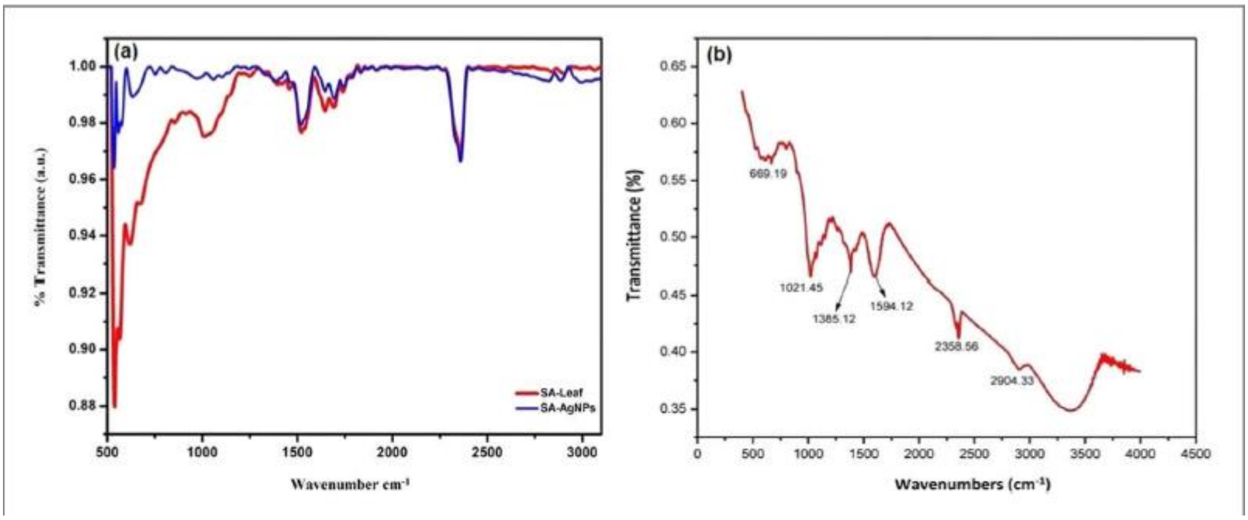

Figure 2.2. FT-IR spectra of (a)SA-Ag NPs and (b)BP-Ag NPs [62,63].

3.3. Scanning electron microscopy (SEM)

Figure 3.4 represents a scanning electron microscope (SEM), which employs an electron beam to scan the surface of a sample and create images [64]. SEM can generate the surface topography and compositional information of the NPs by interacting the electrons and atoms of the NPs [65]. In field emission (FE)SEM, electrons are created in an emission source and accelerated by high electric fields. When a AgNP is scanned, electromagnetic coils generate electrons that pass through a set of lenses to form a focused electron beam and form secondary electrons after contact with the sample's surface. The information contained in the resulting electrons is used to create a highly detailed image of the specimen's surface topography.

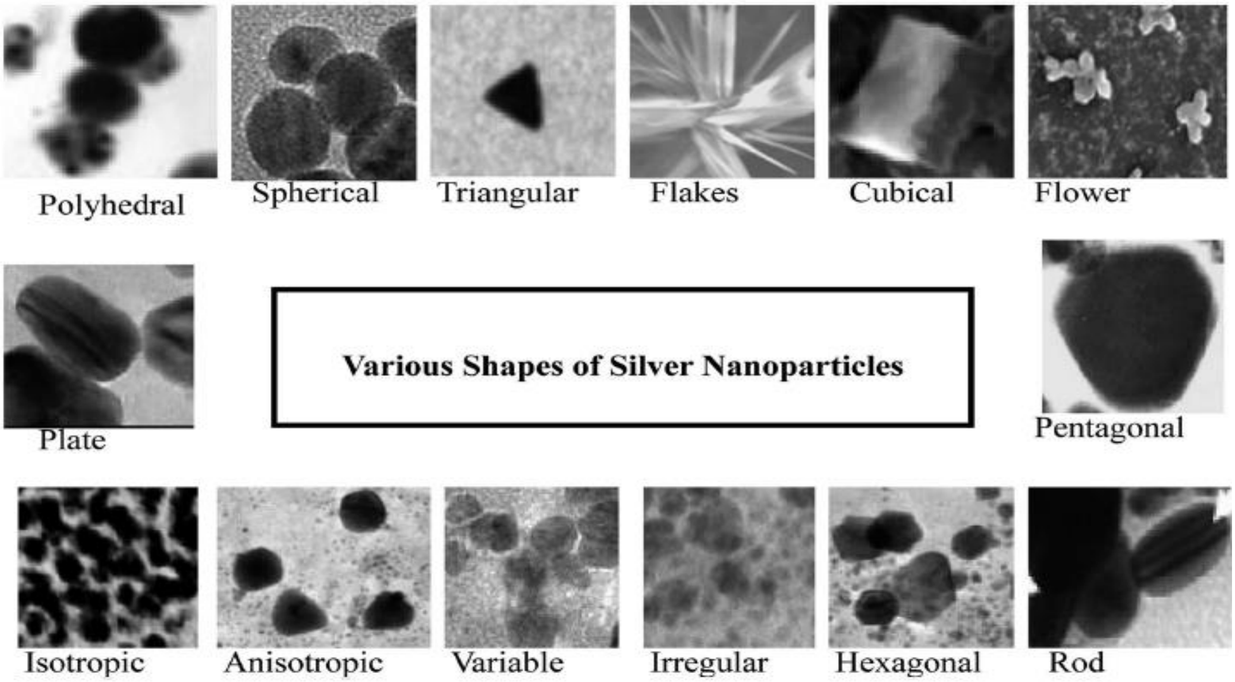

Figure1 3.4 SEM images of Ag NPs synthesized from different sources.[66]

3.4. Transmission electron microscopy (TEM)

Transmission electron microscopy (TEM) is a technique in which an electron beam is passed through a sample and pictures are created as a result of the sample's electrical interaction [67]. The photos are mostly focused on image-detecting fluorescent screens, photographic film, and charge-coupled devices [68]. Materials science, nanotechnology, cancer research, and other study fields all use TEM. TEM is used in nanotechnology research to determine the size and surface shape of nanoparticles.

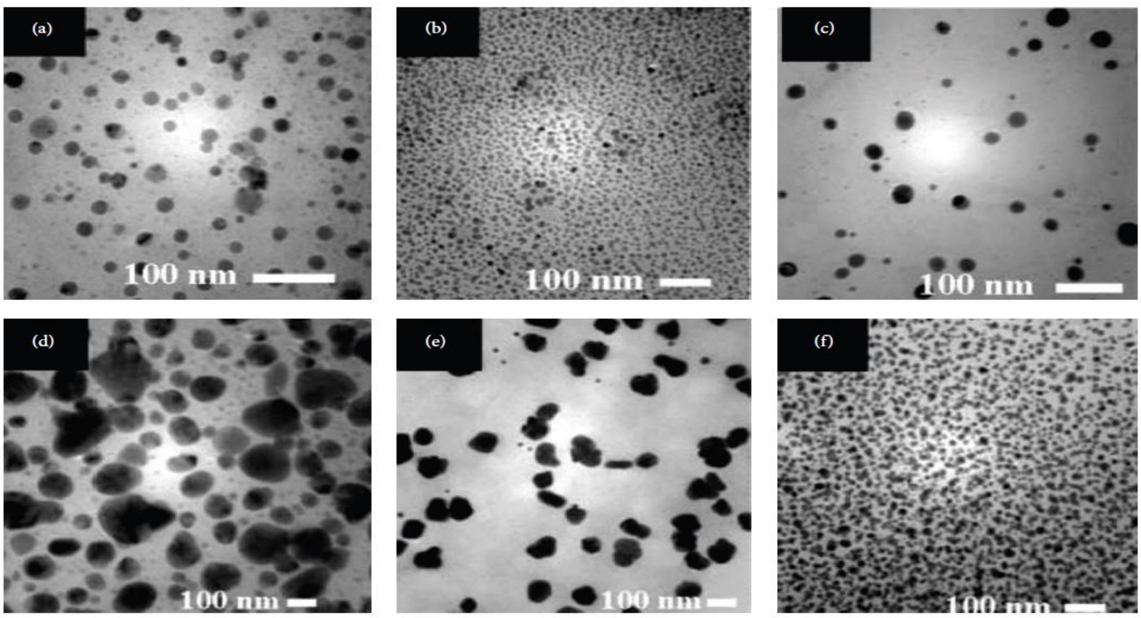

Figure 3.5 : TEM picture of silver nanoparticles manufactured in one step at room temperature using (a) Bigelow tea, (b) Folgers's coffee, (c) Lipton tea, (d) Luzanne tea, (e) Sanka coffee, and (f) Starbucks coffee extract without employing any dangerous reducing chemicals or non-degradable capping agents [69]. 3482980509111 is the copyright license number.

3.5 .X-ray diffraction (XRD)

X-ray diffraction is routinely used to characterize the structure of Ag NPs. The average particle size can also be determined using this method. When monochromatic X-rays hit a crystal, they scatter across the atoms and interact constructively, resulting in a diffracted ray, as shown in figure 9. Diffraction occurs when the path difference between rays scattered from successive planes is several wave lengths. Because every crystalline substance has a unique atomic structure, x-rays diffract in a unique pattern. The diffraction angle is calculated using Bragg's equation [70].

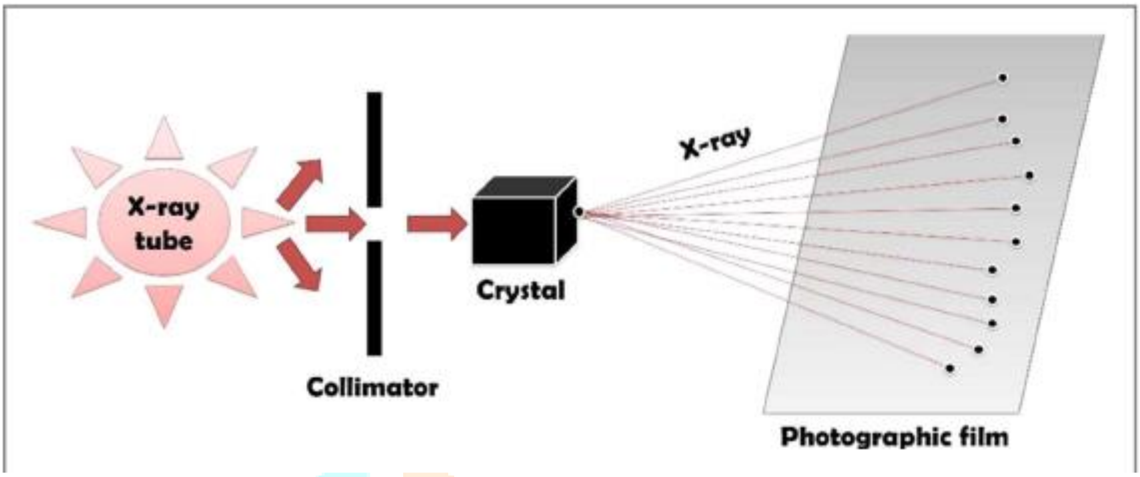

Figure 3.6 .X-ray diffraction pattern in XRD analysis.

4. Applications of silver nanoparticles

Ag NPs have been widely used as antibacterial agents in the health industry, food storage, textile coatings, and a variety of environmental applications. It's worth mentioning that, after decades of use, there's still no solid evidence of silver's toxicity. AgNP-based products have been approved by a number of recognized agencies, including the US FDA, US EPA, and Japan SIAA, as well as in Korea. [71, 72] Ag NPs are also utilized in nanoscale sensors because of their electrochemical properties, which allow for shorter reaction times and lower detection limits. Ag NPs are used as antibacterial agents in a range of applications, including medical device and domestic appliance disinfection, as well as water purification. The textile industry has promoted the usage of Ag NPs in various textile products. Silver nano composite fibers with Ag NPs embedded in the fabric have been created in this direction. [73] Silver nanoparticles impregnated cotton fibers are highly antibacterial against E. coli. Catalytic activities of NPs differ from those of bulk materials; for example, in the presence of sodium borohydride (from 19.74 % to 86.05 %) and a light source, high catalytic activity for decolorization of monochromatic[74] Surface plasmon resonance, which is the collective oscillation of free electrons within metallic NPs, determines the optical characteristics of metallic NPs. [74] The plasmon resonant peaks and line widths are known to be affected by the size and shape of the NPs. In agriculture, Ag NPs are used to increase crop yields, improve plant nutrition, and protect plants from disease. [76] Ag NPs have a wide range of uses, Chen Yu et al. used Ag NPs in catalysis to speed up the reduction of $NaBH_4$ in the reduction of azo dye [77]. Because of their enhanced electromagnetic field on the surface, Ag NPs are frequently used in nanomedicine, including diagnostics, biomedicines, nanoelectronics, and molecular imaging. Ag NPs act as nano antennas because their resonant SPR peak grows with the intensity of the electromagnetic field. Ag NPs function as sensors using Raman spectroscopy to detect any chemical due to specific vibrational modes. number fifty-first, Because of their antibacterial qualities, Ag NPs are used in food packaging to prevent microbial infections. [80,79] Nano sensors for detecting pollutants, colors, and flavors, as well as drinking water and clinical diagnostics, use Ag NPs. [76] Ag NPs have also improved agriculture. Integrating nanotechnology-based smart plant sensors with actuating electrical devices, which optimize and automate water and agrochemical allocation and enable high-throughput plant chemical phenotyping, can boost plant production. Ag NPs are used in plant nutrition and disease defense,[75], and they can be used in agriculture to increase crop productivity by being applied to crops with pesticides. [80] Antifungal, antibacterial, anti-inflammatory, and antiviral therapeutic medicines made of Ag NPs are frequently used. Because of their antibacterial capabilities, Ag NPs can be used in pharmaceutical administration to reduce drug dosages, increase specificity, and reduce toxicity. [81, 82]

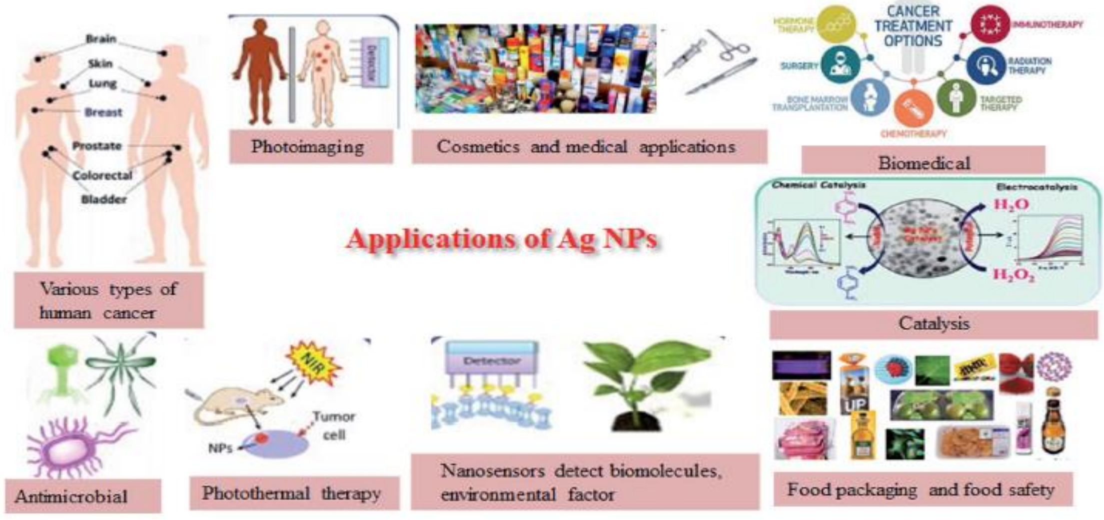

Figure 4.1Various applications of AgNPs.

BIOACTIVITIES

Antimicrobial

As a broad-spectrum antibiotic, silver is extremely toxic to bacteria. It has attracted attention in recent years due to its wide range of pharmacological activity and possible use in agriculture, textiles, and, most notably, medicine. Some put it down to the activity.

fungicidal

Due to bacteria and fungi's resistant pathogenic activities, invasive infections have increased at an alarming rate. The next step is to look for more effective antifungal medications. that is why now a days many researchers are interesting their time and effort to fabricate Ag NPS with varity structures and shapes

Cancer-fighting.

The most important need right now is the discovery of efficient anticancer medicines, because cardiovascular disease is the leading cause of human dysphoria, followed by cancer. As a result, anticancer drug development is crucial.

Anti-inflammatory properties.

AgNPs with a diameter of 20–80 nm were made from Sambucus nigra (blackberry) extract. The anti-inflammatory actions of the NPs were examined in vitro and in vivo against Wister rats using ultraviolet-visible, Fourier-transform infrared, and X-ray diffraction spectroscopy. The result showed that it is promotable to be used as a medication drug component. . [83]

Antiviral Ag NPs

They have a diverse set of biological effects that make them effective antiviral agents. In HEPES buffer, 5–20 nm NPs were produced. The anti-viral activity of Ag NPs following infection in Hut/CCR5 cells was measured using ELISA. Azidothymidine triphosphate [84], a reverse-transcriptase inhibitor, reduced HIV1 retrovirus better than Ag NPs. Antiviral and antibacterial activity was observed in Ag NPs with poly sulfone added. This was due to the release of enough silver ions by the membrane, which worked as an antiviral agent. [85]

Cardiovascular defense

The medicinal herb neem (Millingtonia hortensis) was used to make Ag NPs, which showed strong cardioprotective effects in rats [86]. Characters Wound dressing nanotechnology has made a substantial contribution to wound healing, as wound healing is connected to enhanced anti-inflammatory and antibacterial activities. The use of 22 nm NPs in cotton fabric showed a significant healing effect. [87]. Another step forward in this area was the incorporation of Ag NPs into bacterial cellulose for antibacterial wound dressing. To synthesise bacterial cellulose, researchers used Acetobacter xylinum (strain TISTR 975), which was then immersed in silver nitrate solution. It was effective against both Gram-positive and Gram-negative bacteria. [87] When inorganic NPs are added to a polymer, it increases its performance. In this case, dimethylformamide electrospinning was employed to reduce the amount of silver ions in a polyurethane solution. Collagen was added to increase the protein's hydrophilicity. This collagen sponge injected with Ag NPs increased wound healing in an animal model. [88] Recently, Jacob et al. biosynthesized nano engineered tissue impregnated with Ag NPs, which drastically inhibited borne bacterial growth on the tissue's surface and could aid in the control of health-related infections. [89]

5. CONCLUSION

In conclusion, due to environmental considerations, the green approach to Ag NP synthesis is preferred over traditional procedures. Traditional methods for producing Ag NPs use a lot of energy and potentially harmful chemicals (hydrazine or borohydride as reduction agents) and can produce toxic byproducts. Under ambient settings, the use of biodegradable polymers, sugars or polyphenols from plant extracts, enzymes, and microbes may result in the long-term production of uniform-sized Ag NPs. In comparison to other organisms such as fungi and bacteria, the synthesis of Ag NPs using plants and their extract is rather simple and uncomplicated. AgNPs vary size and shape as reaction circumstances change. When utilized at room temperature, vitamins B2, B1, and C, for example, can produce NPs in aqueous mediums. Furthermore, newer biomimetic approaches for AgNP production have proven to be beneficial, but there are still some inherent safety problems. Green approaches for the synthesis of Ag NPs utilising bio renewable resources show promising because they require non-toxic chemicals for the reduction of silver salt. Plants, bacteria, fungus, and biopolymers were all exploited in the production of AgNPs in the last ten years, according to this summary Ag NPS which is fabricated with green Synthesis techniques is very indispensable to the environment with a double face. i.e will save energy,time and ecology. and used as a catalyst to degrade pollutants which mainly affects environment and human health.

Conflicts of interest
The authors do not have any conflict of interest.

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