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Biosynthesis of silver nanoparticles from bacteria and it's application. Bhagwan Mahavir college of basic and applied science. Bhagwan Mahavir university.

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Abstract:
Nanotechnology has joined an extraordinary interest lately because of its anticipated effect on numerous areas like, medicine , electronics and various different enterprises. Nonetheless, the arising nanotechnology has made a striking effect by converting over metallic silver into silver nanoparticles, for better application. By and large, Silver is considered as a nobel metal utilized for treating burn wound infection, painful injuries, open wounds and cut. Various microorganisms including Bacteria, Fungi, yeast, plants and plant extract, have been viewed as fit for synthesising silver nanoparticles either by intracellular or extracellular. Synthesis of silver nanoparticles has been accounted for by different kinds of methods , including chemical method, physical method and biological method. Synthesis of silver nanoparticles by physical and chemical methods have been utilized toxic chemicals, time and energy consuming, tedious, cost effective and hazardous. however the utilization of biological method manage this issues. The Characterization of synthesize nanoparticles performed through UV-VIS Spectroscopy, Fourier transform infra red Spectroscopy analysis , x-ray diffraction examination, scanning electron microscopy, and high resolution transmission electron microscopy were relatively dissected for their absorbance, stabilisation of bonds, particle size as far as nanometer and particles shapes contributing configuration separately. The microorganisms and plants extract gives different environment to biosynthesis of nanoparticles. These particles are safe and eco-friendly with a heaps of applications in medicine , farming, cosmetic industry, drug delivery , biochemical sensors, antimicrobial activity, biochemical device covering, imaging probes, diagnostics. And furthermore silver nanoparticles have arisen up with different clinical applications going from silver based dressing. Silver covered clinical gadgets, the utilization of silver nanoparticles is additionally significant, as a few pathogenic microbes have created resistance against different antibiotics . This review depict additionally the microorganisms/plants, plants extract and the Synthesis techniques, the portrayal of silver nanoparticles which hold conspicuous effect on their size, shape and application.

Key words:* *Biosynthesis, Silver nanoparticles, Extracellular or intracellular Synthesis, Mechanism, Antimicrobial activity, Application.

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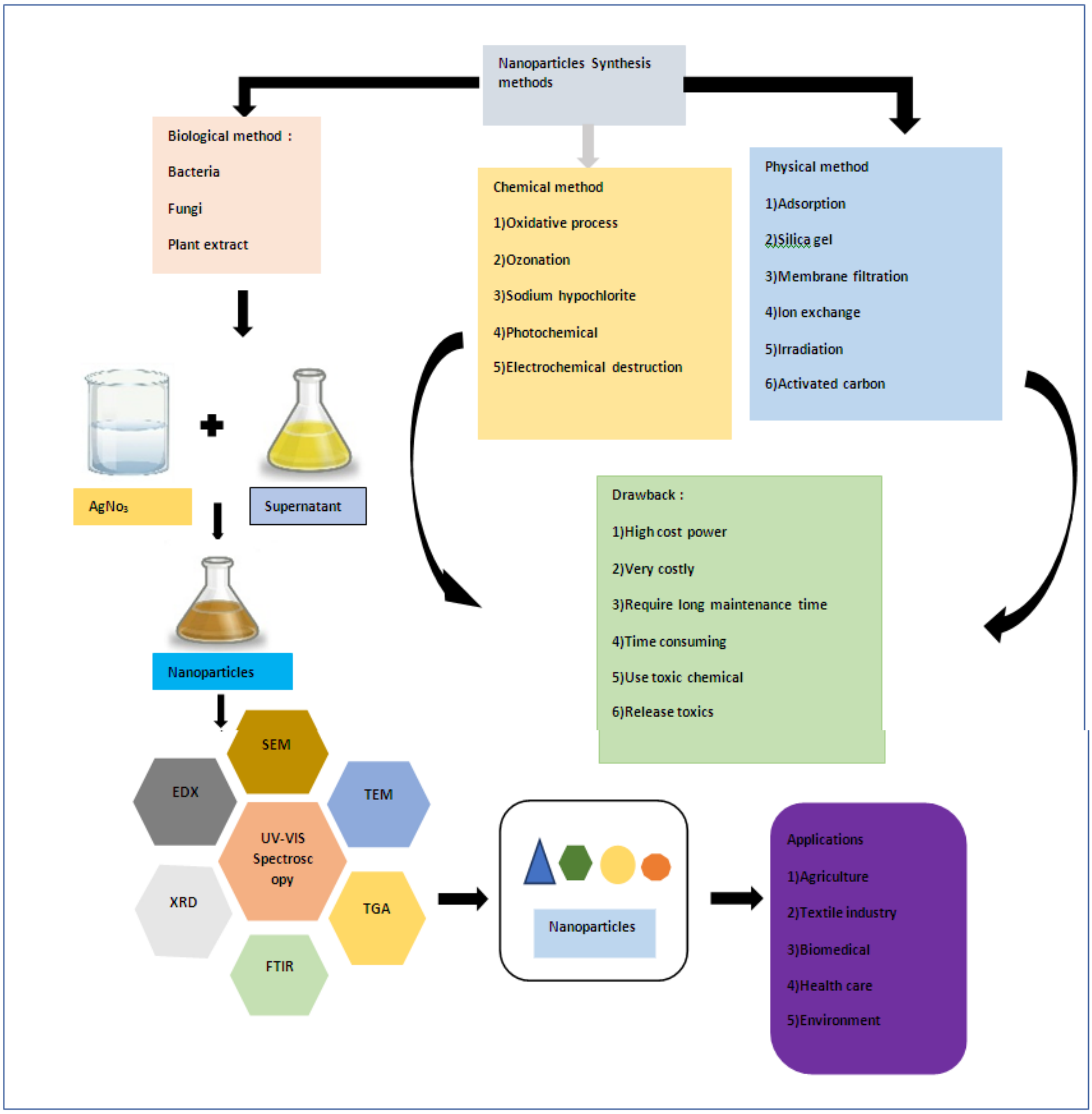

I. Introduction

1.1) Nanotechnology:

Nanotechnology refers to the engineering of materials with nanoscale dimensions to form products with extra accuracy . The enchantment of technology for analysis in the nanometer range led to better understanding of matter[42] . Nanotechnology is an influential sector in the region of interdisciplinary research [72]. The sector of nanotechnology is the very dynamic area of research in material science and the synthesis of nanoparticles is taking up significantly all over the world [73,74].

1.2) History of nanoparticles :

The history of Nanotechnology is quite long. "Nano" Greek word means "Dwarf". The first-time idea of nanotechnology was introduced in1959 by Nobel Prize Laureate, an American physicist Richard Feynman, who gave the Statement that ``There is Plenty of Room at the Bottom." He created a concept And early exploration of quantum computing and creation of devices at Molecular scale. He described the idea of creating things out of tiny pieces (bottom-up approach) instead of making things smaller (top-down approach) at that time.

1.3) Nanoparticles :

In recent years, nanotechnology research is arising as cutting edge innovation interdisciplinary with material science, physics, chemistry, biology and medicine . The prefix nano is gotten from Greek word "*nanos"* signifying " dwarf" in Greek that refers to things of one billionth (10^{-9} m) in size. Nanoparticles are generally 10 nm to 1000 nm in each spatial aspect furthermore, are usually synthesized utilizing two procedures: top-down and bottom up [71,32, 55].

1.3) Top-down approach :

In top-down methodology, the mass materials are slowly separated to nanosized materials [55]. The top-down approach is defined as breakdown of suitable bulk material into Its component parts by size reduction, while the bottom-up approach is based on Self-assembly of atoms to new nuclei which grow into a nanoscale particle [97].

1.4) Bottom-up approach :

while in bottom up approach, particles or atoms are collected to sub-atomic structures in nanometer range. Bottom-up approach is generally utilized for chemical and biological synthesis of nanoparticles [55]. Self-assembly is a bottom-up approach in which atoms or molecules organize themselves into ordered nanostructures by chemical-physical interactions between them. Positional assembly is the only technique in which single atoms, molecules or clusters can be positioned freely one-by-one [97].

1.5) Characteristics of nanoparticles :

The vital characteristics of nanoparticles is their surface area to volume aspect ratio grant them to collaborate with different particles inconvenience free [*55,37,46,*36]. The nano size of materials consequence in determine physicochemical characteristics distinct than those of the volume materials or greater particles [45]. This outcome is mostly praised to high surface-area-to-volume ratio, which consequences in enlarge reactivity, therefore, the nanoscale materials are extra superior than their volume materials [46].

1.6) Physicochemical properties of NPs

The physicochemical properties of NPs are classified as a large surface area, Mechanically strong, optically active and chemically reactive; making the NPs Unique and in demand for various applications [91].

a) Magnetic properties :

Magnetic properties of nanoparticles (NPs) are dominated by two main features, Finite-size effects (single-domain, multi-domain structures and quantum Confinement) and surface effects, which results from the symmetry breaking of The crystal structure at the surface of the particle, oxidation, dangling bonds, surface stain, etc, [93]. The uneven distribution in NPs Leads to magnetic property. This property is dominantly effective when particle Size is 10 -20 nm.

b) Mechanical properties:

The basic mechanical properties of NPs are elastic modulus and hardness, Movement law, friction and interfacial adhesion and their size dependent characteristics. In a lubricated or greased contact, the contrast in the stiffness Between NPs and contacting surface controls whether the NPs are indented into The plain surface or deformed when the pressure at contact is large [92].

C) Electronic and optical properties.

Semiconductor and metallic nanomaterials and nanocomposites possess Interesting linear absorption, photo-luminescence emission, and nonlinear Optical properties. Nanomaterials having small particle sizes exhibit enhanced optical emission as well as nonlinear optical properties due to the quantum confinement effect [92]. These properties are observed to Change at nanoscale level like optical properties. The examples of the change in Electrical properties in nanomaterials are: conductivity of a bulk or large Material does not depend upon dimensions like diameter or area of cross-section And twist in the conducting wire etc.

D) Thermal property:

The metal NPs have the thermal conductivity higher than those of fluids in solid Form. Nanofluids display significantly enhanced thermal conductivity relative To those of conventional heat transfer fluids because the heat transfer takes place At the surface of the particle, and it is desirable to use particles with large surface Area. The large surface area also increases the stability of NPs in suspension [92].

1.7) Classification of Nanoparticles :

NPs are broadly classified based on their morphology, size and chemical Properties. Classification of NPs based on physical and chemical characteristics Is given below:

1) Carbon-based NPs

A broad range of carbon nanostructures have been prepared, such as carbon Nanotubes, fullerenes, nanofibers, nano diamond, carbon, and other Carbonaceous nanomaterials. Carbon nanoparticles have excellent applications Because of their unique chemical and physical properties. [94]. The have unique electrical conductivity, high strength, structure, electron Affinity and versatility which makes them suitable for commercial application Such as filters, efficient gas adsorbent and as a support medium for different Inorganic and organic catalysts [94].

2) Metal and metal oxide

They are purely made of metal precursors. CuNPs, AgNPs, AuNPs, ZnNPs, CuONPs, ZnONPs, NPs are good examples of it. Due to LSPR phenomena, These NPs possess unique optoelectrical properties. Metal oxide nanoparticles Are attractive for a large variety of applications including catalysis, sensors, Optoelectronics materials, and environmental remediation [96].

3) Ceramic Nanoparticle

They are inorganic non-metallic solids, synthesised via heat and successive Cooling. They have been found in amorphous, dense, porous and hollow forms. These NPs may exhibit magnetism, specific optical and dielectric properties, And do not degrade easily, making them useful for bone application [94].

4) Semiconductor Nanoparticles

Semiconductor nanocrystals, based on the periodic table groups into which these Elements are formed. For example, silicon and germanium are group IV, GaN, GaP,GaAs, InP and InAs are III-V, while those of ZnO, ZnS, CdS, CdSe and CdTe are II-VI semiconductors [94].

5) Polymeric NPs:

They are organic based, nanospheres or noncapsular shaped NP applied in Various fields. nanospheres are matrix particles whose overall mass is solid. Where's in nano capsular, the solid mass is encapsulated within the particle Completely [94].

6) Lipid -based nanoparticles:

Liposomal systems are a class of LNPs containing lipids organized in a bilayer Organization. Many membrane lipids, such as phosphatidylcholine (PC), adopt Bilayer structures spontaneously when dispersed in an aqueous medium [95].

The metallic nanoparticles like copper, titanium, zinc [49], magnesium, gold [16], and alginate, Au, Ag, CuAl. Metallic nanoparticles have a powerful bactericidal potential owing to their wide surface-area-to-volume ratio.
In consequence of their extensive feature nanoparticles such as metals, metal ions and semiconductor materials are one type of nanoparticles that have attracted the attention both research and industry, along medical, environmental and pharmaceutical industries [57;58;50].

1.8) Silver nanoparticles :

Silver has been used since ancient periods for it's microbial features. Silver salt have bees used to treat ulcer, burns and chronic wounds, sepsis, acute epididymitis, tonsilitis and infections and prevent eye disease in infants [10;53]. Silver nanoparticles having size in the range of 10-100 nm illustrate the powerful bactericidal potential opposed to both Gram-positive and Gram-negative bacteria. Silver nanoparticles are now one of the most commercialised nanoparticles having application in over 200 products including antimicrobial coating, medical devices, molecular diagnostic and photonic electronics, household appliance, sensor, textile, home water purification, cosmetics, electronics, conductive inks pastes, and filters [27,28,53], also biologically synthesis silver nanoparticles could have numerous applications like spectrally selective coatings for solar energy absorption and intercalation material for electrical batteries [38] as optical receptors [18,23,41] catalyst in chemical reaction [25], bioleaching biological sensor, antimicrobial activity, therapeutics, high sensitivity biomolecular detection and diagnostics, and biochemical application and target drugs delivery [26;51;52;31;44;56;45].

1.9) Methods of synthesis :

Various methods utilized for the synthesis of silver nanoparticles including,

A) Chemical method :

Different chemical methods have been used to for the synthesis of silver nanoparticles including chemical reduction aqueous solution chemical reduction , non aqueous chemical reduction, the reduction, electrochemical reduction, ultrasonic assisted reduction irradiation reduction and photo-catalytic reduction etc [48, 4].
The most widely recognized approach for synthesis of silver nanoparticle is chemical reduction by organic and inorganic reducing agent . By and large, unique reducing agent , such as sodium citrate, ascorbate, sodium borohydride ($NaBH_4$), Elemental hydrogen, polyol process, Tollens reagent, N,N-dimethylformamide (DMF) and poly(ethylene glycol)-block copolymers are utilized for reduction of silver particles (Ag^+) in aqueous or non-aqueous solution . The previously mentioned reducing agent reduce silver particles (Ag^+) and lead to the formation of metallic silver (Ag^0), which is followed by agglomeration into oligomeric bunches. These bunches in the long run lead to arrangement of metallic colloidal silver particles [85,86]. It is crucial for utilize defensive agents to balance out nanoparticles throughout silver nanoparticle planning, and safeguard the nanoparticles that

can be retained on or tie onto nanoparticle surfaces, staying away from their agglomeration. The presence of surfactants containing functionalities (for example thiols, amines, acids and alcohols) for cooperations with molecule surfaces can balance out molecule development, and safeguard particles from sedimentation, agglomeration or losing their surface properties. Polymeric mixtures for example, poly(vinyl liquor), poly(vinylpyrrolidone),Poly(ethylene glycol)poly(methacrylicacid) and polymethyl-Methacrylate have been accounted for to be successful defensive agents to balance out nanoparticles [87].

B) Physical method :

In physical method, metal nanoparticles are by and large synthesized by evaporation condensation, which could be completed utilizing a tube furance at environmental tension. The establishment material inside a boat focused at the heater is disintegrated into a transporter gas. Nanoparticles of different materials, like Ag, Au, PbS and fullerene, have already been delivered utilizing the evolution /condensation method [88] . Nevertheless , the generation of silver nanoparticles (AgNPs) utilizing a tube furnace has a few disadvantages, in light of the fact that a tube furnace consumes an enormous space, consumes a lot of energy while raising the ecological temperature around the source material, and demands a ton of investment to accomplish warm strength. An ordinary tube furnace requires power spending of in excess of a few kilowatts and a pre-warming season of a few many minutes to accomplish a stable working temperature. Also, AgNPs have been incorporated with laser removal of metallic mass materials in arrangement [89, 90,91].One benefit of laser removal contrasted with other regular technique for planning metal colloids is the shortfall of synthetic reagents in arrangements. Subsequently, unadulterated colloids, which will be valuable for additional applications, can be delivered by this technique [90].

But these chemical method and physical methods have been experience along with various side effects, for example, use of toxic solvent, production of hazardous by-product, high energy consumption, which causes hazardous risk to human health and the environment [14, 49].

The synthesis of silver nanoparticles widely studied by using chemical and physical method, but the development of dependable technology to produce broad range of environmentally admissible methodology, low cost production and least time consuming, most of the chemical and physical methods are environmentally hazardous, assets compact as well as inefficient in materials and energy use [25].

Therefore, there is a need to develop clean, non-toxic and environmental friendly methods for the synthesis and assembly of silver nanoparticles [46].

C) Biological method :

It was before reported that numerous microorganisms such as bacteria, yeast, fungi [32,29], plants and plants extract were able to synthesis nanoparticles. Several unicellular and multicellular microorganisms were seen as eco-friendly nano factories to produce silver nanoparticles.

Except fungi, bacteria, yeast, molds, like microorganisms, the synthesis of silver nanoparticles using plant extract is also least time taking but synthesized polydispersed silver nanoparticles because of collaboration of number of components, such as flavonoids, terpenoids, and polyphenols, in the reduction of silver ions [37,52].A curious study demonstrate a simple green synthesis path for silver nanoparticles from silver nitrate salts employing the extract from *jatropha curcos*. Other study, employing *Acalypha indica* leaf extract illustrated that silver nanoparticles synthesis by plant is possible [37].

II. Biosynthesis of silver nanoparticles

2.1) Synthesis of silver nanoparticles from Bacteria :

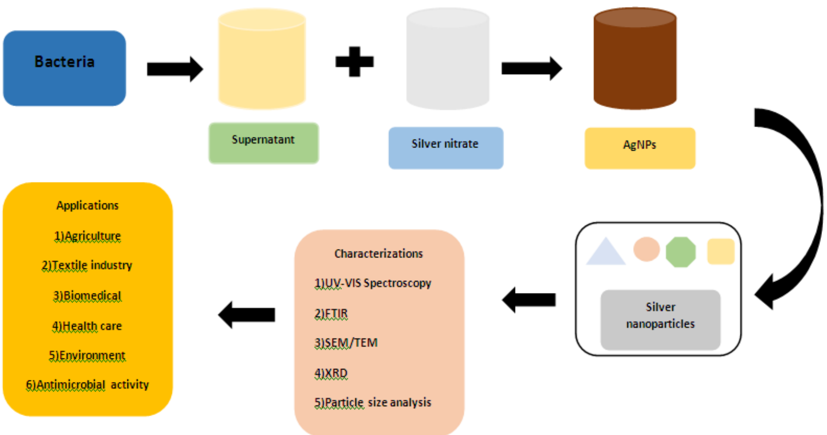

Figure 2: Schematic diagram of synthesis of silver nanoparticles from bacteria.

Inorganic materials are created by microorganisms either extra or intracellular. This makes them likely biofactories for the plan of respectable metal NPs like Gold and Ag. Ag-NPs are known to be biocompatible however some microbes are known to be Ag resistance [54]. Accordingly, these microbes can aggregate Ag on the cell walls, subsequently suggesting their use in modern recuperation of Ag from mineral materials. At first, Ag-NPs were orchestrated by utilizing Ag resistant bacterial strains Pseudomonas stutzeri AG259. These cells gather Ag-NPs in enormous sums upto 200 nm. Ag-NPs were synthesized by utilizing culture supernatants of psychrophilic microbes. Delineated the synthesis of Ag-NPs by Bacillus licheniformis, where the aqueous solution of AgNO3 added to the biomass of B. licheniformis, the color change from whitish-yellow to brown shows the development of Ag-NPs with the size range of 50 nm and were balanced out by protein nitrate. Ag-NPs were likewise synthesized by utilizing culture supernatants of Staphylococcus aureus. Notwithstanding, for speedy combination of Ag-NPs, the way of life supernatants of different microscopic organisms from Enterobacteriaceae can be utilized.

Some bacteria disclose to high metal ion concentration reduce the metal ions or produce complexes with metal ions for their survival. In a few microorganisms, the metabolic pathway is connected with metal ions, which, one by one, needed for the growth of the microorganisms, is responsible for the bio conversion of metal ions to produce nanoparticles [8].The biosynthesis of silver nanoparticles was studied in *Escherichia coli*(ATCC 25922),*Staphylococcus aureus* (ATCC 25923), ampicillin resistant *Escherichia coli*, and multi drug resistant strain of *Salmonella typhus,* and *Escherichia coli* [51], to confirm the reduction of silver ions the solution was examine in the range of 200-600 nm in a spectrophotometer, the size, shape and the characteristics of the silver nanoparticles were scanned with the transmission electron microscope, and scanning electron microscope, the *Escherichia coli* used as a source of microorganisms to synthesize silver nanoparticles by extracellular, also the changing the color of the solution confirm the reduction of silver ions and synthesis of elemental silver, and the particle size analyzer gives the details about the particles feature, like monodispersed, di-dispersed and polydisperse. The above study confirms that the nanoparticles are polydisperse, and have size variation between 40 to 60 nm [46,21,34].

The synthesis of silver using Gram-positive and Gram-negative bacteria belonging to the families of *Bacillaceae* and *Enterobacteriaceae* [41], to confirm the production of silver nanoparticles, The culture flask were primarily observed for the color change from colorless to brown color, the primary identification done by phenotypic characteristics of bacteria under microscope, for the further confirmation of reduction of silver nanoparticles, the solution was examine under UV-VIS Spectrophotometer at 300-700 nm, the size and the shape of the synthesis silver nanoparticles were scanned using transmission electron microscope, every nanoparticle crystal has their own X-ray pattern, the sample first freeze dried and for analyze under X-ray diffraction at diffracted intensities from 30° to 80° angles [41].

Although some *Bacillus sp*. like *Bacillus pseudomycoides* MT32 [24], also used for synthesis of silver nanoparticles was isolated from the atmosphere by the exposure with aqueous silver nitrate and the confirmation of reduction of silver ions was examine under transmission electron microscope in both the magnification low and high magnification. Biological production of silver nanoparticles 10-15 nm in size were observe in the periplasmic space of the bacterial cell, which is present in the outer and inner cell (plasma) membrane. From the above observation of transmission electron microscope indicates the reduction of Ag+ ions to elemental silver in the plasma membrane and the size of synthesis silver nanoparticles is between 5-15 nm. The silver nanoparticles was characterize by using UV-Vis spectrophotometry between 200-1000 nm, to observe surface Plasmon resonance, for detection of pattern of crystal nanoparticles X-ray diffraction were used, Scanning electron microscope and transmission electron microscope used to analyze the size, shape and features of synthesis silver nanoparticles [12,43].

Another strain of *Escherichia coli* (ATCC 8739)and *Bacillus subtilis* (ATCC 6633) [59], *Streptococcus thermophilus* ESh1 [60] utilized for the production of silver nanoparticles, the bacterial supernatant carried out. The color change in the medium suggested the formation of silver nanoparticles. All the three strain shows the rapid reduction of silver ions within the 5 minute contact with the silver ions. Which is more faster than other strain of microorganisms and fungi. Extracellular biosynthesis occurs by these bacteria have advantage other than fungi and intracellular synthesis method. The color intensity increased with the increased Incubation time, the flask without silver nitrate does not show any color change which means the formation of silver nanoparticles was not occurs, and the flask was used as control, this phenomenon shows that few reducing agents are responsible for the reduction of silver ions to form silver nanoparticles in the culture flask. UV-VIS – spectrophotometer show the absorbance of all three test strain is between 420 and 430 nm for silver nanoparticles synthesized by bacterial strain, X-ray diffraction shows the crystal nature of the silver nanoparticles and show the peak of four ranging values from 20° to 80° angle. The size and the shape of synthesized nanoparticles was determine by transmission electron microscope and scanning electron microscope, the size of silver particle were show in the range of 5-25 nm [13].

The strain of *Bacillus subtilis* (PTCC 1023), *Lactobacillus acidophilus* (PTCC 1608), *Klebsiella pneumoniae* (PTCC 1053), *Escherichia coli* (PTCC 1399), *Enterobacter cloacae* (PTCC 1238), *Streptococcus aureus* (PTCC 1112) used for the synthesis of silver nanoparticles, the reduction of silver ions and the synthesis of silver nanoparticles was determine by the observing the change in color of media from pale yellow to brown, the changing of media color only shows in the flask containing strain of *Klebsiella pneumoniae*, *Escherichia coli*, *Enterobacter cloacae*. And no color change of the media containing the strain of *streptococcus aureus*, *Bacillus subtilis*, *Lactobacillus acidophilus*. The appearance of brown color determine the reduction of silver ions and the synthesis of silver nanoparticles, this is proved that some metabolic by product or some reducing agent are responsible for the reduction of silver ions and synthesis of silver nanoparticles. The features and characteristics of silver nanoparticles was analyzed by UV-VIS Spectrophotometry for Escherichia coli, *Klebsiella pneumoniae* and *Enterobacter cloacae*, was shows powerful, but wide surface Plasmon peak located at 419,430 and 420 nm respectively. Transmission electron microscopy and scanning electron microscopy used to determine the shape and size of silver nanoparticles from range between 50-100 nm [32].

Among all the microorganisms, *Escherichia Coli* (S30, S78), *B. Megaterium*(S52), *Acinetobacter sp*. (S7), S. *Maltophillia*(S54), used for the synthesis of silver nanoparticles. To confirm the reduction of silver ions by all the strains was determine by the UV-Vis spectrophotometer after 7 days of Incubation, the UV-Vis spectrophotometer demonstrate the silver nanoparticles in the range of 250-650 nm. The surface Plasmon resonance peak ranging from 2 to 100 nm. The transmission electron microscope and scanning electron microscope determine the size of silver nanoparticles between the range of 15-50 nm [57].

2.2) Synthesis of silver nanoparticles from Fungi :

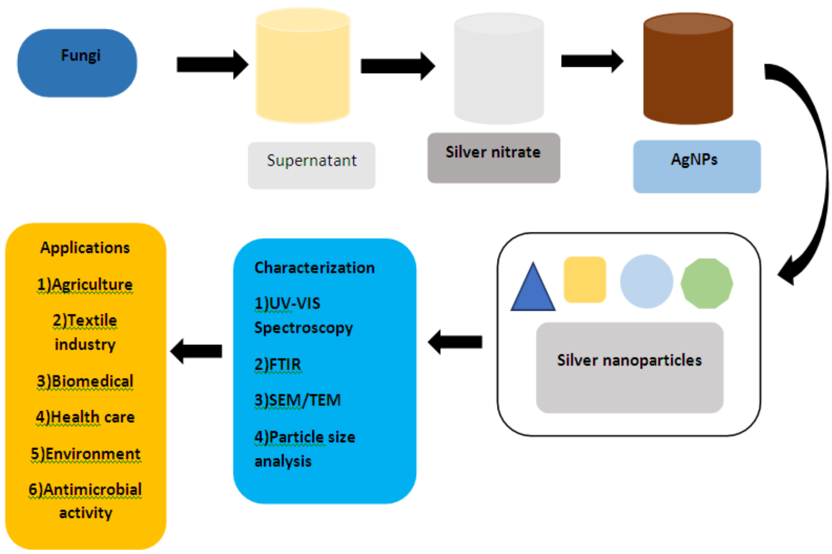

Figure 3: Schematic diagram of synthesis of silver nanoparticles from fungi.

Fungi have potential for the amalgamation of metallic NPs due to metal bioaccumulation capacity and their resistance, high resistance capacity , and intracellular take-up like microscopic organisms that are not difficult to deal with in an exploration facility as contrast with Bacteria [75]. Fungi can be utilized through various techniques for the synthesis of NPs, in which fungus discharge number of enzymes which are used to reduced $AgNO_3$ solution [29]. A schematic portrayal is displayed in figure.

The extracellular synthesis of Ag-NPs by using *F. oxysporum* and its antibacterial impact on textile fabrics is studied by [76]. Detailed that mono-scatter Ag-NPs can be synthesis by utilizing fungus *Aspergillus flavus* and normal size of the NPs saw in the range of 8.92 ± 1.61 is estimated by Transmission Electron Microscopy (TEM) [77]. The extracellular synthesis of Ag-NPs utilizing fungus *Cladosporium cladosporioides* is seen by Balaji et al. also, the size of NPs is seen by TEM in the range of 10-100 nm [78]. In another technique, represented in vitro synthesis of Ag-NPs involving AgNO3 as a substrate and *Penicillium fellutanum* segregated from coastal region of mangrove residue. Studied on that aqueous Ag particles when presented to the *Fusarium oxysporum* are reduced in solution by an enzymatic process, provoking the development of profoundly stable Ag hydrosol [79]. The NPs are in the size range 5-15 nm and are settled in arrangement by protein-emitted parasite. The extracellular synthesis of mono-scattered Ag-NPs is accomplished by Bhainsa and utilizing *Aspergillus fumigatus* at speedy amalgamation rate. In another strategy, round Ag-NPs are combined by [80]. *Aspergillus terreus* with a typical size of 1-20 nm.

2.3) Synthesis of silver nanoparticles from plants:

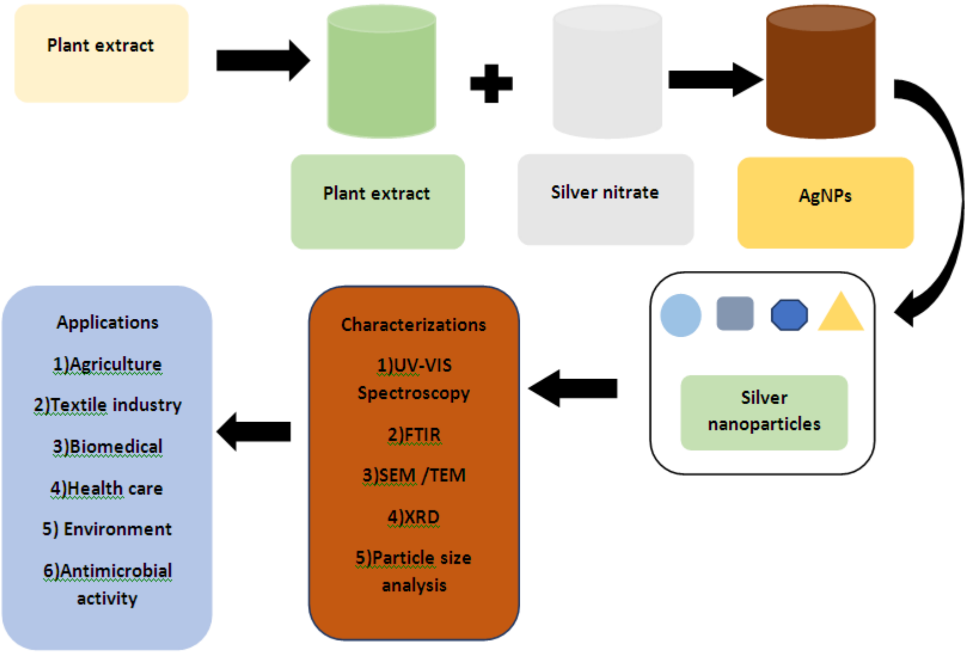

Figure 4: Synthesis of silver nanoparticles from plant extract.

[81] delineated that the first approach of involving plants for the synthesis of metallic NPs was finished by utilizing Alfalfa sprouts, which was the first description about the synthesis of Ag-NPs utilizing living plant system . Alfalfa roots have the capability assimilate Ag from agar medium what's more, journey them into shoots of plant in same oxidation state. In shoots, these Ag molecules organized themselves to produce Ag-NPs. [82] announced that Ag-NPs are synthesis by using Ananas comosus (pine apple juice) as settling as well as reducing agents and synthesized NPs were characterise by High Resolution Transmission Electron Microscopy (HRTEM), UV-Vis spectrometer, Energy Dispersive X-ray Spectroscopy (EDX), and chosen Area Diffraction (SAD). TEM micro graph represented the round NPs with a typical diameter of 12 nm. Ag-NPs are synthesized by using Argemone mexicana leaf extract as capping as well as reducing agent by adding to the aqueous solution of AgNO3. The properties of NPs are examined by utilizing UV-Vis spectrometer, X-Ray diffractometer (XRD), Scanning Electron Microscopy (SEM), and Fourier Transmission Infrared (FTIR) Spectrophotometer. [83] showed that XRD and SEM uncovered the average size of NPs as 30 nm. Studied on that Ag-NPs were synthesized by the reduction of aqueous AgNO3 solution through the extract of Neem and Triphala and characteristics of NPs were investigated by utilizing EDX, nanoparticles following investigation (NTA), and TEM. NTA and TEM uncovered the circular particles size range of 43 nm and 59 nm [84].

III. Mechanism of synthesis of silver nanoparticles :

In this article we have seen that many microorganisms including bacteria, fungi, have the ability to reduce the silver ions in elemental silver. The conversation from silver ions to elemental silver is not well understood, but there is some research proposed that few fungi and bacteria have enzymes that reduces the silver ions, enzyme called NADH depended nitrate reductase. NADH depended nitrate reductase enzyme only able to reduce silver ions in *F. Oxysorum* fungi [2,1], whereas no reduction were occurs by NADH depended reductase enzyme in *F. moniliforme* fungi. In the same way, some microorganisms are able to reduce the silver ions in elemental silver. In bacteria the synthesis of silver nanoparticles were occurs by two way, synthesis of silver nanoparticles using bacteria were done by electrostatic interaction and the second way is the secretion of substance that will adhere the ions. The bacteria synthesized silver nanoparticles either by intracellular or by extracellular . The ions trapped in the cell of the bacteria, the electrostatic interaction occurs between ions and bacterial cell because the bacterial cell have negative charge and ions have positive charge. Secretion of substance that will adhere to the cell wall of bacteria will stabilize the ions to the cell of the bacteria. NADH depended nitrate reductase enzyme released by bacteria which reduce the silver ions to form elemental silver to prevent bacterial cell damage. The bacteria reduce the silver nanoparticles by mean of intracellular or extracellular, in the extracellular synthesis of silver nanoparticles, the bacterial cell containing the proteins in the cell wall acting as reducing agent and some enzymes also associated in extracellular biosynthesis. The enzymatic reduction includes NADH and FADH which donates electron and in non-enzymatic reduction includes various group of polysaccharide or polypeptide like, aldehyde, ketones, carboxyl and amides are responsible for the reduction of silver ions to elemental silver forms [58,52,41, 61].

Characterization of NPs:
Different Characterization techniques have been used for analysis of various Physicochemical properties of NPs given below;

Purpose	Technique Used	Reference
Morphological Characterization	SEM,TEM, Polarized Optical Microscopy (POM)	[13,51]
Structural Characterization	XRD ,EDX, Zeta Size analyser, SEM,TEM, FTIR	[12,21,13, 57]
Particle Size and surface Characterization	SEM,TEM, Atomic Force Microscopy (AFM), XRD , DLS, Nanoparticle tracking analysis (NTA)	[12,56, 51]
Optical Characterization	UV -Vis Spectrophotometry, Photoluminescence, Diffusion Reflectance Spectroscopy (DRS)	[12,21, 57]

Table 1 :Techniques used for characterization Of NPs

IV. Application of silver nanoparticles :

Silver nanoparticles have several application.

4.1) Antimicrobial Activity :-
The antimicrobial activity of silver nanoparticles have been used in different application such as, health industry, textile coating, surgical masks, bandages, disinfectant, water treatment and so on. Silver nanoparticles shows antibacterial activity and antifungal against large range of gram-positive and gram-negative bacteria, yeast , like, *Bacillus subtilis*, *Bacillus cereus*, *Enterobacteriaceae* family, *Staphylococcus aureus*, *Staphylococcus epidermis*, *Streptococcus thermophilus* and *Escherichia coli*, *Klebsiella pneumonia*, *pseudomonas aeroginosa*, *salmonella sp*., *Shigella flexneri* and *vibrio cholera* respectively. For the testing of antifungal and antimicrobial activity of silver nanoparticles various method used to determine their activity. For that zone the metallic silver likewise neglected to work on the antimicrobial action of inhibition were observe by disk diffusion and agar well diffusion method. Another is minimum inhibitory concentration by both macro dilution and micro dilution assay, minimum bacterial concentration etc [39,46,34].

4.2) Wound dressing :
Silver nanoparticles used in clinical treatment in various injuries, like, burns, chronic ulcers, pemphigus, and toxic epidermal necrolysis and also used in wounds dressing [44].

4.3) Dentistry :
Silver nanoparticles used in dentistry instruments and bandages, silver nanoparticles can least the microbial colonization of coating materials, enhance the antifungal potential [44].

4.4) Silver dressing :
Dressings have a significant influence in the administration of wounds [63]. As of late, the advancement of safe strains of microbes has turned into a significant issue and the recently planned wound dressings has given a significant forward leap to the treatment of contamination and wounds. The antibacterial properties and the harmfulness of silver to miniature living beings is notable, hence, presently a day's , silver is utilized in various types of details like surface covering specialists, wound dressing and so forth The silver dressings utilize conveyance frameworks that delivery silver in various focuses. Be that as it may, various variables like the appropriation of silver in the dressing, its synthetic and actual structure, liking of dressing to dampness additionally impact the killing of microorganisms [46].

4.5) Silver coated textile fabrics :
In the beyond couple of many years, scientists are checking out the advancement of material textures containing antibacterial agent . As, silver is non-poisonous and groups antimicrobial properties it has urged laborers to utilize silver nanoparticles in various material textures. Toward this path, silver nanocomposite strands were ready containing silver nanoparticles fused inside the texture however from the it was reasoned that the to check electron minuscule review it silver nanoparticles fused in the sheath part of textures had critical antibacterial property contrasted with the textures consolidated with silver nanoparticles in the center part [69]. Comparative outcomes were acquired by utilizing silver nanoparticles on polyester nonwovens. The fact that silver nanoparticles makes it in like manner detailed covered material textures have antibacterial movement against S. aureus [46].

4.6)Silver toxicity :
Harmfulness from silver is seen as argyria, just when there is a huge painful injury and huge measure of silver particles are utilized for dressing. There are no normal reports of silver sensitivity [63]. Silver nanoparticles in

many investigations are recommended to be non-poisonous. Be that as it may because of their little size and variable properties they are proposed to be dangerous to the climate [70]. Concentrated on the poisonousness of various sizes of silver nanoparticles on rodent liver cell line (BRL 3A) (ATCC, CRL-1442 deified rodent liver cells). The creators tracked down that after an openness of 24 h the mitochondrial cells showed strange size, cell shrinkage and unpredictable shape. Cytotoxicity investigation of silver nanoparticle impregnated five economically accessible dressings was embraced by. In the review, it was tracked down that three of the silver dressings portrayed cytotoxicity impacts in keratinocytes and fibroblast societies. Detailed the harmfulness of silver nanoparticles on C18-4 cell, a cell line with spermatogonial undifferentiated organism attributes. From the review, it was presumed that the cytotoxicity of silver nanoparticles to the mitochondrial movement expanded with the expansion in the centralization of silver nanoparticles [46].

4.7]Medical applications:

One use of silver ion or metallic silver as well as silver Nanoparticles can be exploited in medicine for burn treatment, Dental materials, coating stainless steel materials, water Treatment, sunscreen lotions, etc [76].

4.8]Other applications:

•Silver has been known to have solid antimicrobial properties both in its metallic and nanoparticle shapes subsequently, it has tracked down assortment of utilization in various fields [46].

• The Fe3O4 joined Ag nanoparticles can be utilized for the treatment of water and effectively eliminated utilizing attractive field to stay away from defilement of the climate [15].

• Silver sulfadazine portrays better mending of copy wounds because of its gradual response with serum and other body liquids [61].

•The nanocrystalline silver dressings, creams, gel actually diminish bacterial diseases in ongoing injuries [62,63].

The silver nanoparticle containing poly vinyl nano-filaments likewise show proficient antibacterial property as wound dressing [64].

•The silver nanoparticles are accounted for to show better twisted recuperating limit, better surface level appearance and scarless recuperating when tried utilizing a creature model [65].

• Silver impregnatedmedical gadgets like surgicalmasks and implantable gadgets show huge antimicrobial adequacy [66] .

•Natural amicable antimicrobial nanopaint can be created [67].

• Silver nanoparticles can be utilized for water filtration [68].

V. Conclusion :

The present study conclude that various microorganisms can be used as a source of synthesis of silver nanoparticles by either intracellular or extracellular. The biosynthetic method for synthesis of silver nanoparticles have been recognized as an alternative to chemical and physical synthesis method. Because of this biosynthetic method is economical, eco-friendly and cost-effective and biosynthetic silver nanoparticles are helpful as antimicrobial agents, and also applicable in many of the applications. To obtain silver nanoparticles synthesis bacteria is also eco-friendly and cost-effective. Biosynthetic method is easy to perform than the chemical and physical method.

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