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Review Article

Comparative Study of AgO Nanoparticles Synthesize Via Biological, Chemical and Physical Methods: A Review

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Abstract: Nanotechnology is the cutting edge and modern emerging technology due to its wide range of applications in many fields of sciences and technologies like ceramics industry, cosmetics, detergents, fertilizers, mobile devices etc. Metallic nanoparticles are considered the building blocks of nanotechnology. Among the metallic nanoparticles, silver nanoparticles are considered to be the more emerging nanoparticles due to its wide range of applications. Nanomaterial's have unique optical, catalytical, and electromagnetic properties. Nanotechnology provides a platform for the engineers to synthesize nanoparticles and to know the properties of by characterizing the size, morphology status to produce potential multitude products. To get maximum and unique size and morphology of nanoparticles, different procedure i.e. synthetic routes and optimal conditions are being choosing to get maximum nanoparticles e.g. pH, temperature, concentration of supernatant, concentration of extract, method employing for the synthesis of nanoparticles and time of stirring. The aim of this review article is to comparative study of different method of nanoparticles synthesize. The fast and more reliable method is Biosynthesize method due to Eco-friendly, cost efficient.

Keywords: Nanotechnology, Nanoparticles, Antifungal Potential, Biosynthesis

1. Introduction

Nanotechnology is the cutting edge and modern emerging technology due to its wide range of applications in many fields of sciences and technologies like ceramics industry, cosmetics, detergents, fertilizers, mobile devices etc. Metallic nanoparticles are considered the building blocks of nanotechnology. Among the metallic nanoparticles, silver nanoparticles are considered to be the more emerging nanoparticles due to its wide range of applications [1]. Nanomaterial's have unique optical, catalytically, and electromagnetic properties. These widely has been studied to assess the effect of antifungal or antibacterial among gram positive or gram-negative bacteria and so others. Metallic nanoparticles have increased the market value due to many of its products like cloths, mirrors, optics, electronics, catalysts, photography, food preservatives, and food packaging materials. Silver nanoparticles also have wide range of applications like as an anti-inflammatory, antiseptic, antimicrobial and cytotoxicity activity [2].

Nanotechnology provides a platform for the engineers to synthesize nanoparticles and to know the properties of by characterizing the size, morphology status to produce potential multitude products. Many nano-products have been explored like optical tubes in the nanotechnology, optical rods, labels for cells, cancer therapeutics, biosensor etc. It has been noted that the optical, electromagnetic and catalytically properties of silver nanoparticles determine the size and shape of nanoparticles. With the development of synthetic routes and nanoparticles, assembly like hard template, solution phase and bioreduction allows us to control a better yield by controlling the size and morphology of nanoparticles. AgO nanoparticles have attractive physico-chemical properties and has got attention due to unique properties among the other metallic nanoparticles. Silver nanoparticles have individual scattering that enable to ideal molecular labeling due to surface Plasmon resonance effect. Now silver nanoparticles have strong toxicity that exhibits in many chemical forms that promising to be an antimicrobial material [3].

To get maximum and unique size and morphology of nanopaticles, different procedure i.e. synthetic routes and optimal conditions are being choosing to get maximum nanoparticles e.g. pH, temperature, concentration of supernatant, concentration of extract, method employing for the synthesis of nanoparticles and time of stirring. Now there are present a number methods like physical, chemical and biological methods for the synthesis of metallic nanoparticles. Among them, physical and chemical methods using heavy reducing agents such as sodium borohydride, hydrazine, and organic passivators like thiourea, thiophenol that causes hazardous effects to the environment if they get synthesized at large scale. In every status, it must be need to control the pollution free and the clean, environmental friendly, less toxic products by using alternative methods for the assembly of nanoparticles [4].

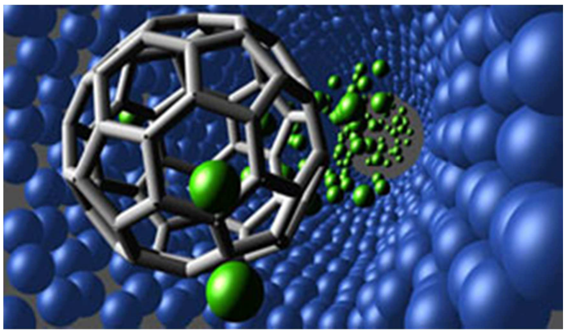


Figure 1. *Nanotechnology [5].*

Noble metals such as gold, platinum, silver etc have significant properties than other elements, but their functions totally got changed while at nanoscale. The change in size of noble metals at nanoscale changes the physical and chemical properties. It can be adjust by scheming the parameters like size distribution ratio, composition of building material, and shape of moulds etc. Many techniques make noble metals distinctive from other elements due to optical, magnetic and electrical properties [5].

Nanoparticles are the smallest particles having size that varies from 1nm to 100nm. Nanoparticles (NP) are defined as natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm–100 nm [6]. Due to their high surface to volume ratio, nanoparticles are being widely used as catalyst in many industries. Nanoparticles have been proved as a catalyst by many studies against the antimicrobial effect that indicate the significance of high surface to volume ratio. Nanoparticles are of great attention due to small size, mass to charge (m/c) ratio, volume to surface (v/s) ratio, optical absorption, and electrical conductivity that changes physico-chemical properties from the bulk material [7, 8].

Silver nanoparticles are the smallest particles of silver that have a dimension vary from 1nm to 100 nm. Ag NPs have been widely synthesized among the engineered nanoproducts due to wide range of applications in consumer products [9]. Ag nanoparticles as a good biocide, used in nanofillers, catalysts, cosmetics antibacterial and antifungal agent [10].

Figure 2. *Ag nanoparticles [1].*

Silver nanoparticles have idiosyncratic physical and chemical properties like thermal, electrical, surface enhanced Raman scattering SERS, catalytical activity, and optical properties [11]. Being to have these above properties, silver nanoparticles have been employed in microelectronics, microchips, microinks, bioassays, medical imaging [12]. Silver nanoparticles show fungicidal and bactericidal properties [13] so that various consumer products have been made including cosmetics, soaps, foods, textiles and plastics that increasing the market economy [14].

Due to unique properties, Ag nanoparticles have been employed in surgical instruments, as a therapeutic, anti-bacterial and anti-fungal agent, as a catalyst to remove dyes, fluorescent labels, transfection vectors, and modifier to DNA, medical devices or instruments, drug delivery systems [15]. Ag nanoparticles are considered to be the prominent group of nano materials due to wide range of applications, unique physico-chemical properties and diverse drug delivery system than other nanomaterials [16].

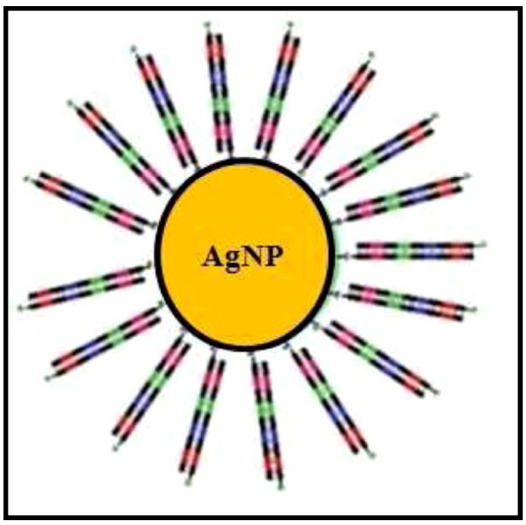


Figure 3. *Conjugate DNA–silver nanoparticle [17].*

Now a day the chirality of Ag nanoparticles got more attention to revolutionize the advancement in nanotechnology and to improve the consumer products. Ag nanoparticles got more attention that is significant for synthesis and characterization of optically active, chiral and Ag capped with ligand. Ag nanoparticles are assigned for the colorimetric sensing of analytes due to surface plasmon resonance effect. In addition gold nanoparticles, silver nanoparticles have significant chirality that distinguished the physico-chemical properties of nanoproducts like extinction coefficient, Surface Enhanced Raman scattering (SERS), Surface Plasmon Resonance absorption (SPR) and biocompatibility. The wide range applications of Ag nanoparticles includes pollution cleanup, easy childbirth, reduce mortality rate, improve immunity system and it stop aging process [18].

Turmeric is a herbaceous plant of the ginger family (Zingiberaceae), known also as 'curcuma domestica.' A perennial herb of the ginger family, with small stems and pellet leaves the turmeric measures up to 1 meter long [19].

Table 1. *Taxonomical Classification of Curcuma longa.*

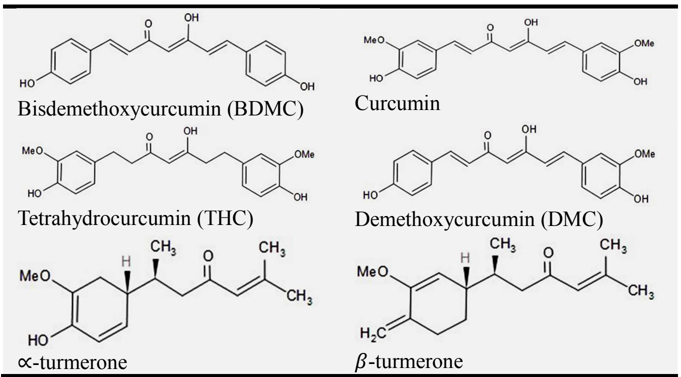
Kingdom:	Plantae
Clade:	Tracheophytes
Clade:	Angiosperms
Clade:	Monocots
Clade:	Commelinids
Order:	Zingiberales
Family:	Zingiberaceae
Genus:	Curcuma
Species:	C. longa
Binomial name	Curcuma longa

Curcumin is diffuloyl methane that is contained in plant extracts. The yellow turmeric and curry powder is responsible for curcuminoids. They come from ethanol extraction from turmeric [18]. Curcumin for study and for clinical trials (courcumin mixture) is commercially available, which contains 77% pure curcumin (cur), 17% demethoxycurcumin (DMC) and 3% bisdemethoxy curcumin (BDMC). In addition, one of the most important metabolites is tetrahydro curcumin (THC) when cells are treated with curcumin [20].

Figure 4. *Turmeric (Curcuma longa).*

Commercially available curcumin used for research and for clinical trials (curcumin mix) contains 77% pure curcumin (Cur), 17% demethoxycurcumin (DMC) and 3% bisdemethoxycurcumin (BDMC). Additionally when cells are treated with curcumin, one of the major metabolites is tetrahydrocurcumin (THC) [21]. A significant degradation product is expected to be the trans-6-(4-hydroxy-3-methoxyphenyl)-2,4-dioxo-5-hexenal, which is known as a minor degradation product of vanilline, ferulic acid, and feruloylmethane. With the incubation time, the amount of vanillin improved. Many studies have shown the antioxidant and anti-inflammatory effects of curcumin [22].

Table 2. *Various phytochemicals of Curcuma longa [19].*



The major Phytochemicals in *C. longa* powder were polyphenols. According to a study (Shishodia et al., 2007), the possible mechanism for the synthesis of AgNPs was also explained by−OH groups [23] of curcumin in the *C. longa* extract. These phytochemicals possessed high reducing agents along with strong antioxidants for the reduction of Ag+ ions to AgNPs. The reduction process determined by due to the electron-donating ability of phenol hydroxyl [24].

Figure 5 demonstrates the mechanism for AgNPs formation using *C. longa* extract. Firstly, Ag+ ions formed an intermediate complex with −OH groups of curcumin and then oxidized curcumin into ketone form with the release of free electrons and Ag+ ions. Nextly, these Ag+ ions reduced to zerovalent Ag. Finally, obtained AgNPs were stabilized by curcumin in the extract [2, 25].

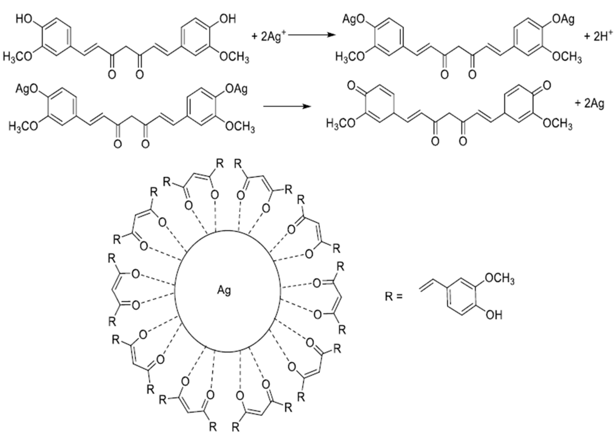


Figure 5. *Mechanism for the synthesis of silver nanoparticles.*

Since the synthesis of the first nanoparticles, their applications have reached many diverse fields of research. The largest group of chemicals produced worldwide are synthetic textile dyes and other industrial dyes [26]. Dye effluents pollute rivers [27], stream and the atmosphere [28]. This pollution would impact marine species and biological processes in the river [7, 28].

The catalytic effect of Silver Nanoparticles sponsored by Silica has been shown in the figure 6. The findings and assumptions of this article are used to compose this section. In order to catalyze [29] the decreases in sodium borohydride ($NaBH_4$), silver nanoparticles immobilized on silica spheres were examined. Dyes have been picked so a difference of color will quickly be observed as the dyes are reduced [30].

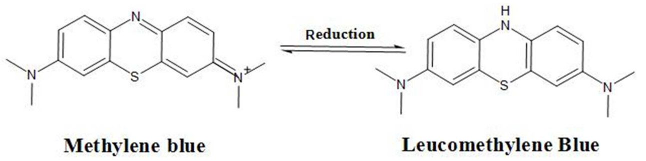


Figure 6. *Conversion of Methylene Blue to Leucomethylene Blue [24].*

The reduction of methylene blue has been prominently affected by the presence of NPs as catalyst. This reduction reaction is easily studied by the UV-visible spectroscopy [30].

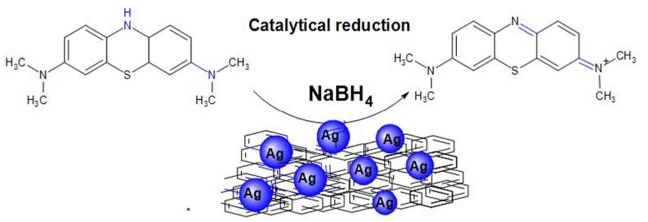


Figure 7. *Supposed mechanism for methylene blue to leucomethylene blue.*

The absorption at 664 nm is the first order of kinetics. The catalytic properties of the NPs can be used to compare the various NPs but their mechanism remains to be resolved. Just the surface region is considered to be specifically connected to the catalytic potentials [31]. The amount of coordinate metal atoms increases by decreasing the specific dimension, which enhances the adsorption of reactants on the surface of the catalysts. The metal nano catalyst with intermediate redox potential makes fast transition of electron from the donor to the accepting device [32]. AgNPs are popular for anti-fungal, anti-inflammatory and anti-viral activities. The inactivation of microbes by nanoparticles Ag is known to prevent cell proliferation by interacting with their enzymes, proteins or DNA [33].

The synthesis of NPs and their application in the allied field have become the favorite pursuit of all scientists, including biologists, chemists and engineers. It is understood that almost all plant shrubs or trees containing fragrance, latex, flavonoids, phenols, alcohols and proteins are capable of producing metal nanoparticles from metal salts. While nanoparticles can be chemically synthesized by conventional methods, biosynthesis prevents the atmospheric pollution [34].

2. Literature Review

2.1. History of Nanotechnology

The idea of nanotechnology was first and foremost raised by Richard P. Feynman in his famous speech on the bottom in Caltech in 1959. In 1974 the Japanese materials scientist Norio Taniguchi invented the term 'nanotechnology.' The theory of nanotechnology was first explored conceptually in the 1980s by Kim Eric Drexler, an American MIT physicist. The field of nanotechnology is increasingly expanding as an interdisciplinary science which includes biologic, medical, environmental and physical sciences [35]. Other uses include biosensor development in manufacturing, biomedical products, renewable energy generation and environmental restructuring. Nano-structures are non-metallic as well as metallic are the product of various innovative applications, such as thin layers, nanospheres, nano-rods and other nanoparticles [36].

It is actually possible to define nanotechnology as one billionth of an a meter. Nanotechnology is a technology to develop, characterize, synthesize, deploy and control shape and size in nanometer scale of materials, structures, devices or systems. It is able to function at the chemical, molecular and supramolecular levels and develop and use new material, structural, instrumental, and systems characteristics. Nanotechnology is scientifically used for the identification of materials, devices and systems with structures and components with new physical and chemical and biologic features that are significantly enhanced, as well as phenomena and processes that enable the control of nanoscale characteristics [37].

2.1.1. Why Silver

High conductivity and low resistance of the malleable and ductile of natural occurring silver has various oxidation states. Silver with zero or +1 is stable and plentiful, but less common and unstable with +2 or +3. Gonorrhea, gastroenteritis, tobacco addiction, epilepsy and mental illness are the numerous diseases treated by Ag NPs [38]. As silver finds new uses, particularly in textiles, it is likely that silver demand will increase, changing the trend of silver production as these innovations, chemicals, and medical industries and goods expand across the worldwide economy. The low silver ion concentration exhibits low toxicity. In comparison with metallic silver, silver ions are more toxic [39].

2.1.2. Importance of Silver Nanoparticles

1) The properties of these nano particles are antimicrobials, bio-labelling, chemical reaction catalysts, optical sensors, electrical battery intercalation materials and solar energy absorption coatings.
2) Drug distribution, imaging, bio-sensing and air technologies have indeed been employed in quality and purification control [40].
3) Bimolecular detection and diagnostic devices of catalysis and micro-electronics, antimicrobials and therapeutic applications and good selectivity [41], since these silver nanoparticles are cytotoxic [42].
4) Surgical instruments, bone prostheses, contraceptive devices, and wound dressings [43].

2.1.3. Comparison of Silver Oxide Nanoparticles with Other NPs

Silver shows the highest amplitude of the Plasmon resonance band on the surface than all other NPs, such as copper and gold [44]. Both AgO NPs and gold NPs are typically used for optical detection to have a surface resonance effect. AgO NPs demonstrate a sharper and stronger Plasmon resonance peak than Gold NPs [45], as their Surface Plasmon resonance performance is higher in particle concentration than in bulk. AgO NPs have now improved sensitivity for applications such as surface-enhanced Raman or localised surface plasmone resonance. The plasmon surface emission of Gold NPs ranges from 500 nm to 600 nm [46], while most fluorophores emit more than 500 nm. Fluorescence can be extinguished when fluorescent colours are adjacent to the surface of the particles [47]. This form of fluorescence squeezing occurs rarely on AgO NPs because the surface absorption of AgO NPs is usually less than 500 nm. AgO NPs have better fluorescent lights than gold NPs [48]. Thus, some observable fluorescence can be extinguished. When fluorescent colours are parallel to the top of the atom. This form of fluorescence quenching occurs rarely in AgO nanoparticles [49], because the surface absorbance of ag nanoparticles is generally below 500 nm. For this objective, AgO NPs have a greater fluorescent signal than au nanoparticles [53].

2.2. History of Ag Nanoparticles

The word "nano" derives from the Greek word which means a very little object. It constitutes one billionth of the unit (10^{-9}). The Nanoparticles (NPs) are materials which may be metals, ceramics, polymers and composites, with 1-100 nm of nanometer scale. In contrast with bulk materials they show special optical [54], chemical [55], and mechanical properties due to surface plasmon resonance [56] and surface-enhanced Raman scattering resonance effects. Nanoparticles are used in a wide range of areas, such as robotics, biotechnology, fiber engineering and water treatment due to their special characteristics. They are usually used in medical catheters and wound dressings. A number of personal care items now include AgNPs, such as make-up, toothpastes, shampoos, air sanitizer sprays, bedding and garments [57].

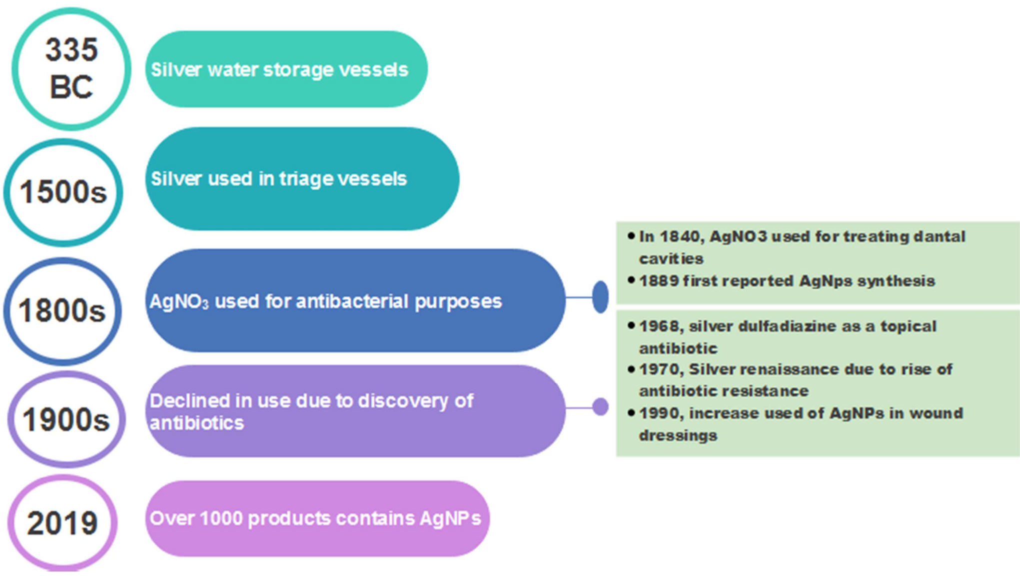


Figure 8. *Timeline depicting the usage of silver products throughout history.*

The high surface-to-volume ratio makes silver nanoparticles an excellent choice in numerous consumers' goods [50] excellent antimicrobial agents. This would mean that AgNP production and consumptions of the products containing them will keep growing in the future. In the references above the words "nanoscale, nanotechnology, and nano-object" have become Feynman's modern concept of the speech. On December 29, 1959, Feynman lectured "there's plenty of rooms at the bottom" during a meeting of American physcial society [51].

Junk and Riess found Feynman's attribution to nanotechnology as deceptive in explaining the historical context to Feynman 's speech, the State of the Art in 1959 and Feynman's inspiration, stating that Feynman intended only to create microbiologic machines and instruments to help scientists imitates microbiological materials [52].

In ancient Egypt and Rome there is anecdotal evidence on the use of nanosilver. In order to enhance wound healing [58], the Macedonians used silver plates and Hippocrates used silver for ulcer treatment. Eye drops were used to treat eye infections in newborns with a one percent silver nitrate solution [59]. The pure liquids such as water, wine, vinegar and milk have been historically noticed to be increased when in silver vessels have been stored [60]. United States colonists later placed silver dollars into buckets of milk to stop spoiling milk [61]. Colloidal nanosilver in the USA has been used in the drugs for nearly a hundred years in the suspension of the liquid silver crystals, which was reported as biocidal material in 1954. This long history of nanosilver and its complex uses have contributed to substantial scientific studies on its chemical and atmospheric properties [62].

2.3. Classification of Nanoparticles

2.3.1. Composition

Single or composite of materials are classified by composition [63]. They can be found in nature as agglomerations of materials with various compositions. However, pure single-composition materials can be easily synthesized today by a variety of methods [64].

2.3.2. Morphology

The following classifications are based on morphological characteristics of nanoparticles: flatness, sphericity and classification between high-and-low aspect ratio particles (aspect ratio). Nanotubes and nanowires, containing shapes like helices, zigzags [65], belts [66], or possibly nanowires with diameter that varies with length are examples of high aspect ratio nanoparticles [67]. On the other hand, spherical, oval, cubic, prism, helical or pillar, collections of many particles existing as powders, suspension, or colloids are classified under small-aspect ratio morphologie [63, 64].

2.3.3. Dimensionality

Dimension-based classification within the nano meter range was built to handle zero-dimensional structures (nanopores and nanoparticles) [64], a direction-bound one-dimensional framework (layered or laminated structures), usually thin films or surface coatings used in computer chip circuits and eyeglass coatings [65], a two-dimensional framework restricted in two dimensions (filamentary structure). In comparison, free particles are often considered with a wide aspect ratio of measurements in the nanoscale range [66]. In the three dimensional framework, however, the three dimensions (structures composed of consolidated equiaxed crystallites) are confined [67]. These involve thin films deposited under conditions that create porosity on the atomic scale, colloids and free nanoparticles [68].

Table 3. *Classification of nanoparticles.*

Dimensionality	Criteria	Examples
Zero-dimensional (0D)	The nanostructure has all dimensions in the nanometer size range.	Nanoparticles, quantum dots, nanodots
One-dimensional (1D)	One dimension of the nanostructure is outside the nanometric size range	Nanowires, nanorods, nanotubes, nanoneedles, typically thin films or surface coatings
Two-dimensional (2D)	Two dimensions of the nanostructure are outside the nanometric size range. 2D nanostructures display plane-like structures	Nano-coatings, thin films and nanolayers and asbestos fibres
Three-dimensional (3D)	Three dimensions of the nanostructure are outside the nanometer size range. Consists of nanocrystalline units with properties on nanoscale as a result of size effect	Bulk different distributions of nanoparticles and nanocrystallites

2.4. Techniques for Nanoparticle Synthesis

A wonderful area of research interest in the field of nanotechnology has recently been the development of many stable methods for nano-particle synthesis, by testing scale, shape and chemical composition. Nanoparticles connected with organic molecules promote the mutual existence and the creation, which also gave considerable emphasis to science, of various dimensional (1-D, 2-D, 3-D) meso-structures.

Table 4. *Different methods to synthesize nanoparticles.*

Bottom-up approach	Top down approach	
Green methods (Non toxic)	**Chemical methods (Toxic)**	**Physical methods (Toxic)**
Using bacteria	Chemical reduction	Pulsed laser ablation
Using microorganism	Coprecipition	Lithography
Using enzymes and biomolecules	Solvothermal	Pulse wire discharge
Using yeast	Microwave	Vapour and gas phase
Using plant and their extracts	Pyrolysis	Ball milling
Using fungi	Electrochemical	Spray Pyrolysis
	Photochemical	Arc discharge
	Microemulsion	Evaporation–condensation

The following methods are used for the synthesis of nanoparticles typically used solid, liquid, or gas precursors to create different nano-structured materials. The methods of synthesis of nanoparticles are classified mainly into two approaches: top-down and bottom-up are shown in figure 10. The top-down method involves the physical processes such as baking, grinding, etc., in which bulk particles split up into smaller and smaller particles. Whereas, owing to crystallographic injury during the nanostructure formation [69], this technique has a detrimental effect on the surface structure. In the bottom-up technique, chemical and biological methods such as sol-gel [70], laser pyrolysis, plasma spraying method, and green synthesis method are used. Through adding atom to atom, molecule to molecule [71], or cluster to cluster, nanostructures are created where nanoparticles are created at basic atomic or molecular stages. The bottom-up approach is fabulous to the creation of uniform structures and distributions for nanostructure materials and compares better with the top-down approach [72].

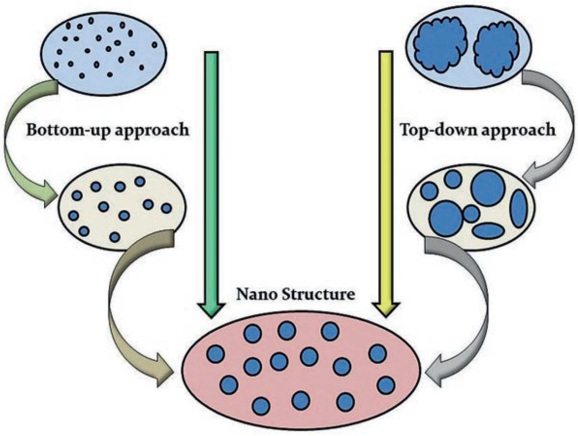


Figure 9. *Basic approaches for nanoparticle.*

2.4.1. Physical Methods

(i). Mechanical Milling Method

In the late 1960s, John Benjamin and his colleagues at the International Nickel Corporation produced a synthesis of materials from high-energy powder ball milling. This work aimed at producing high temperature structural applications with complex Oxide Dispersion Reinforced (ODS) alloys. Mechanical milling process mainly associated with powder processing with the application of medium or high speed agitators. Air jets composed of small particles formed from the bilk material [73]. Ball milling is a good direction of mechanical milling [74].

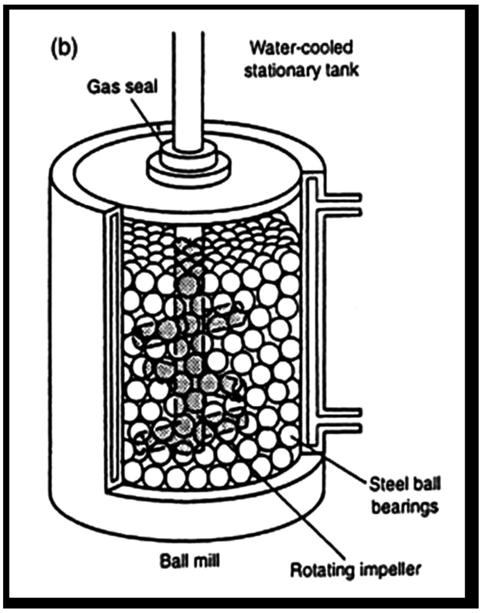


Figure 10. *Ball Milling Method [39].*

(ii). Physical Vapor Deposition

Physical vapor deposition is a technique for producing gas-phase nanostructures through a focused electrons beam which heats the bulk parent material in parent form. This approach is non-catalytic for the synthesis and creation of final development by parent agency, such as sputtering, laser elimination, laser pyrosis, etc [75], no chemical reaction occurs again from beginning to end of the process [48]. Sputtering and thermal evaporation are the two most frequent PVD methods. Thermal evaporation is a deposition technique which uses sufficient vacuum methods to vaporize the source material by heating the material [76].

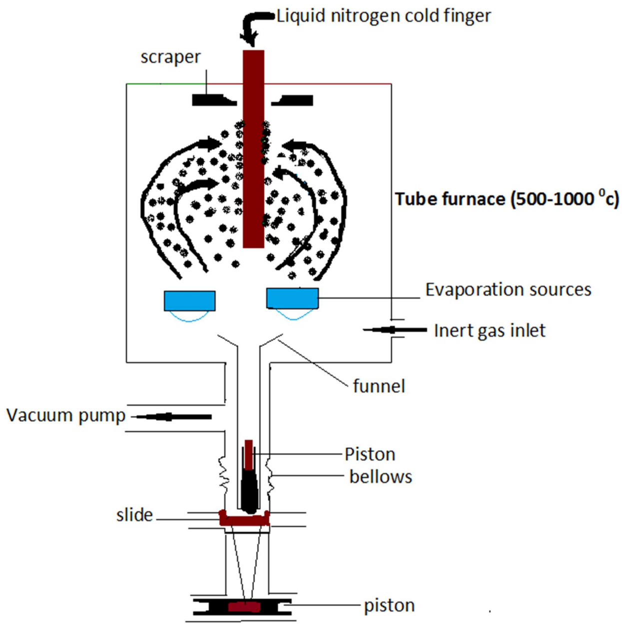


Figure 11. *Physical vapor deposition method.*

(iii). Laser Ablation

Laser ablation is the process by which a solid (or even liquid) material is stripped away by irradiating it by a laser pulse. The absorbing laser beam at low-intensity laser flux, evaporating or sublimating it, subjects the sample. In general, this portion in large laser streams is converted into plasma. Laser ablation usually involves the replacement of material using a pulsed laser [77], but if the Laser power is too high, the material can be filled [78] with a continuous laser wave beam. Laser ablation is a type of laser beam that produces a nanostructure in the high vacuum system, which melts and evaporates materials such as metals and compounds [79].

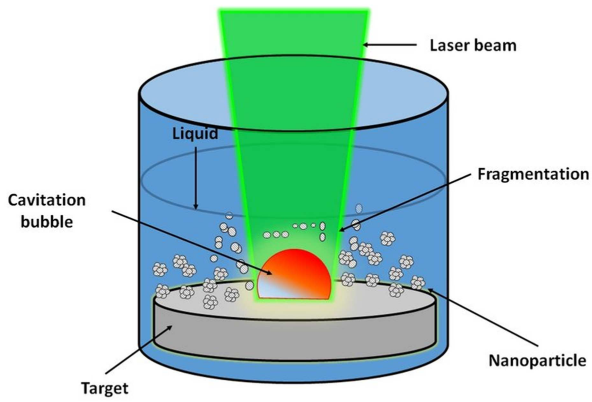


Figure 12. *Laser ablation method [44].*

2.4.2. Chemical Method

(i). Sol-Gel

Sol-gel is a chemical process used for the synthesis of gel and precipitation and calcination of nanoparticles respectively. In the form of colloidal aggregates [80] this gel is configured from stabilized grounds owing to the presence of soils in the form of minute, aqueous metal oxy-hydroxy particles. However, this aggregation can be isolated in the presence of certain capping agents [80]. Hydrolysis and condensation have a regulated function during system gelation. Temperature, pH, precursor of metal ion solution etc., depend on the various physical or chemical parameters of the hydrolysis and condensation [81].

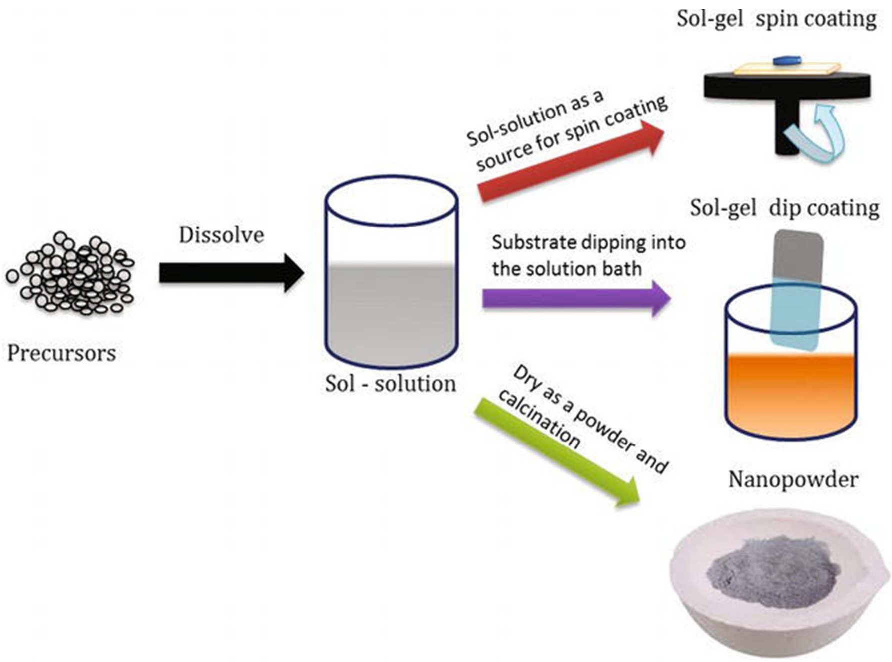


Figure 13. *Schematic diagram of sol-gel processing [45].*

(ii). Co-precipitation

Simultaneously occurring nucleation, formation, coarsening and agglomeration processes include co-precipitation reactions [81]. The materials are normally insoluble produced under high standard conditions. Nucleation is a crucial step in the creation of a vast number of small particles [82]. Secondary processes such as maturation and accumulation in Ostwald have a dramatic effect on the product scale, morphology and characteristics. The conditions required super saturation to cause precipitation typically result from a chemical reaction [46]. This method is simple and convenient, particle size and composition can be easily regulated. Different options for changing the surface condition of particles and general homogeneity. It needs low temperature and productivity in energy [79, 83].

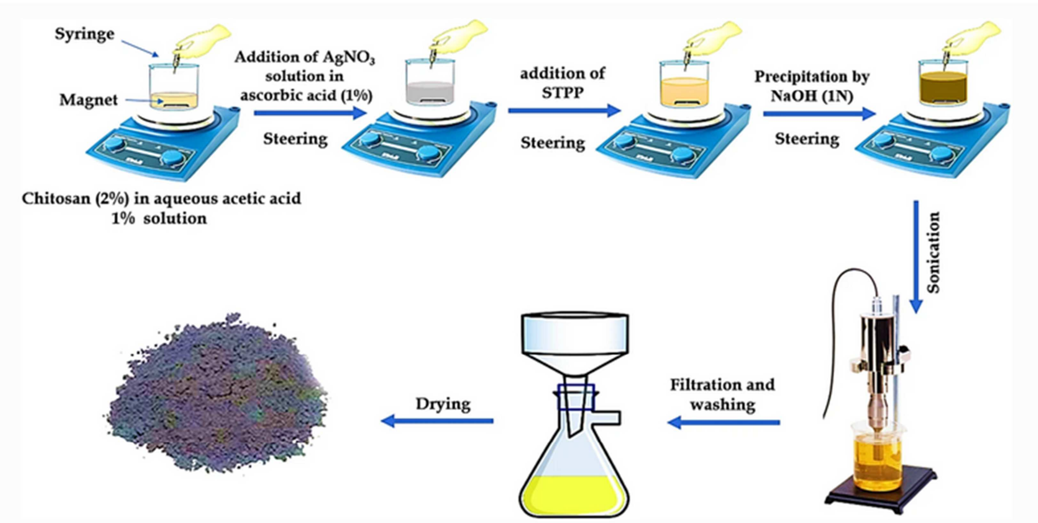


Figure 14. *Preparation of Chitosan AgNPs via co-precipitation method [4].*

2.4.3. Green Method

Traditional techniques are constrained by different drawbacks such as expensive methods, dangerous toxic chemicals generation, high temperature and pressure requirements, etc [83]. Researchers are currently concentrating on the biological systems and favor green synthesis because of such disadvantages of conventional approaches [5, 84, 85]. Green synthesis is a cost efficient and environmental-friendly way for nano structural materials to be synthesized with flexible shapes, morphologies and distribution of particle size [86]. Green processes use plants, bacterium, and fungal species to synthesize nano materials and thanks to their less harmful and high costs effects, this is a very rapidly expanding field of science [87].

Green chemical techniques have led to providing reliable and environmentally friendly alternatives to traditional chemical and physical synthesis by biological processes with the aid of bacteria, fungi, plant extracts or refined bioactive compounds. During the formation of nanoparticles by plant extracts [6, 89] it was observed that at the low pH value, the nucleation rate of metal ions was very low and the agglomeration in the metal nanoparticles was possible to generate large nanoparticles due to a low pH level [88]. The formation of plant extracts relied on various chemical and physical parameters such as pH, temperature, etc [53, 89].

Table 5. *Green synthesis of Ag-NPs using plant and plant extracts.*

plant extracts	Precursor	Reducing and capping agent	Size (nm)	Structure/shape	References
Helicteres isora	$AgNO_3$	Root extract	30–40	Crystalline and spherical	[54]
Rheum palmatum	AgNO3	Root extract	121±2	Cubic, spherical and hexagonal	[55]
Excoecaria agallocha	$AgNO_3$	Leaves extract	20	Crystalline, hexagonal and spherical	[56]
Banana	$AgNO_3$	Peel extract	23.7	Crystalline and spherical	[57]
Eiucalyptus globulus	$AgNO_3$	Leaves extract	1.9–4.3	Spherical	[58]

2.5. Studies on Green Synthesis of Nanoparticles

In 2018 Goutam et al. used the anatase step of green titanium dioxide (TiO_2) NPs using Jatropha c*urcas L.* The fabricated anatase step of the spherical TiO_2 NPs demonstrates the involvement of phytochemicals in the leaf extract, which may require capping/stabilizing NPs. Satyavani K et al. 2011 used *Citrullus colocyn* for the biosynthesis of silver nanoparticles. The therapeutic potentials, antimicrobial [7], anti-inflammatory [8, 79] anti-diabetic and anti-oxidant effects of *Citrullus colocynths* have been reported in our laboratory [9, 88]. The precise mechanism of the synthesis of silver nanoparticles by plant extracts is not yet fully known. Only the participation of phenols [10], proteins and reducing agents in their [11] synthesis has been hypothesized [60, 67]. A combination of the laser ablation and chemical syntheses has been used to synthesize nanoparticles [8]. Irradiate samples with the same wavelength where the nanoparticles reveal their full absorption, by detonating the plasmon resonance surface, photograph the bactericidal impact [44].

R. Sankar et al. reported an antibiotic, wound-healing anticancer, photocatalytic, and activity of the medicinal herbal extract of the aqueous leaf mediated platinum, copper oxide, and titanium dioxide nanoparticles [12, 45] Fluorescent nanoparticles from natural metals were successfully synthesized with C in this work [7, 20]. Powder of long tuber. As a reduction agent for the formation of nanoparticles [13], long tuber powder of bioactive compounds has been used and thus fluorescence of the particles has been decreased [8, 90]. Silver nanoparticles showed smaller, mono colloidal particles and a wide potential distribution of the Zeta in the colloidal solution among the various metal nanoparticles. Silver nanoparticles, by contrast, have a facially centered, crystalline cubic structure. Furthermore, studies in fluorescence and fluorimeter microscopy have shown that silver nanoparticles have produced high levels of fluorescence and are absorbed actively by A549 cells of the lung. The economically efficient, sustainable and environment friendly and highly fluorescent silver nanoparticles can be used as an innovative medical agent especially in diagnostic cancer [88, 89].

The anisotropic structure of the nano floor has been found to possess the highest EF compared with other types. They found that curcumin acts as a dual role, capping and reducing agent. No other external reduction agents, such as $NaBH_4$, ascorbic acid or hydrazine etc are essential. The synthesis of form-selective Ag NPs with curcumin was used as potential materials for the SERS analysis [90].

It is understood, that the remediation of toxic matter by reduction of AgNPs in aqueous $AgNO_3$ is dependent on microorganisms such as bacteria and fungi [63]. The biological process is commonly known as a new nano technological branch and is called nano-biotechnology. AgNP biosynthesis is a bottom-up approach [14, 19, 21] involving reducing/oxidation reactions in particular. As the reaction takes place in one stage, molecules that have two characteristics are favored today [10, 15] i.e. reducing and capping agents [3, 5, 16, 25]. The three key sources involved in the bio-synthesis of AgNP are the bacteria, fungi and plant extracts. Several AgNP synthesis studies have been documented using bio-materials, including plant extracts and micro-organisms [64, 65].

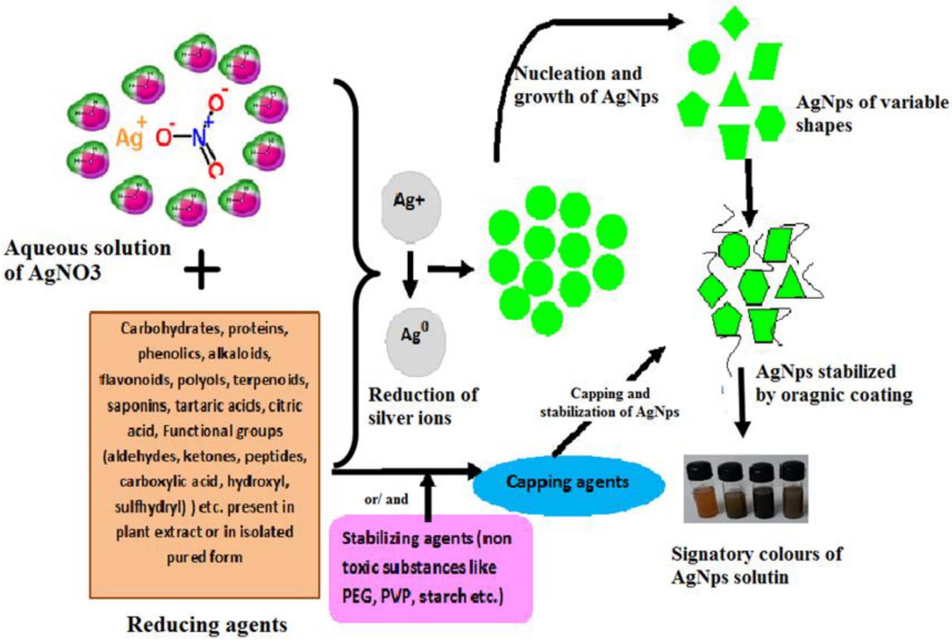


Figure 15. *Possible mechanism for the biosynthesis of silver nanoparticles.*

Bacteria are strong candidates for AgNPs synthesis. The synthesis of the AgNPs with the strain Pseudomonas stutzeri AG259 isolated from the silver mine was first reported in Hefei [17, 56]. During reduction, the enzyme nitrate reductase enzyme transforms nitrate into nitrate, and the electron is converted to a silver ion; thus it reduces to silver (Ag^+ to Ag) ion [91].

In order to enhance its inherent properties, silver nanoparticles (SNPs) have become one of the most interesting materials for research and development [18]. This noble nano-metal is known for its unique properties which make it applicable to several applications such as electronics, photonics, photo catalysis [33, 19], superficial enhanced Raman spectroscopy (SERS) detection [18, 20], biosensor detection [92].

2.6. Optimization of Conditions for the Formation of NANOPARTICLES

2.6.1. Effect of pH

Earlier studies have shown that biosynthesized nanoparticles are manipulated by adjusting the pH of reaction mixtures, both in size and in shape [34]. The pH reaction's ability to alter the electrical charges of biomolecules [45], which can affect their capture, stabilisation and ultimately the growth of nanoparticles, is a major influence. This effect could lead to the favorable formation of nanoparticles of specific forms in a specific pH range in order to achieve greater stability. The authors have shown that alkaline conditions seem to be more effective for producing triangular and horizontally formed golden Nano plates in an acid pH, and that Nano plates' structures were not easily detectable in studies of pear fruit extract-assisted room-temperature biosynthesis [69, 70].

The effect of pH on the size of Ag nanoparticles has been demonstrated in several studies. Ag nano-particles with Curcuma longa powder and extract, large Ag nanoparticles were developed with a lower pH, while large and small nano-apartments were formed at a higher ph, [71] At an alkaline pH, the use of large numbers of negatively charged functional groups for Ag binding which facilitated the binding and formation of a large number of cationic Ag(I) In acidic pH, however, Ag nanoparticles were expected to form larger nanoparticles over the nucleation, which led to the formation of large nanoparticles [74, 93].

2.6.2. Effect of Temperature

Several studies showed that temperature regulation was important in the direction of the shape and size of nanoparticles during the plant-mediated synthesis process. Luckman et al. reported that *Medicago sativa* seed exudates could only generate Ag Nano triangles at temperatures above 30°C due to suppression [94] of form-directing agents at lower temperatures. A further example of the crucial role of reaction temperature in the form-directing process has been shown in the formation of Ag nanowires mediated by Cassia fistula leaf broth [95]. As suggested by the scientists, the interaction between biomolecules and silver faces could be altered at elevated temperatures and thus impede the coalescence of nanoparticles in a solution that is not conducive to the formation of Ag nanowires [71, 96].

2.6.3. Effect of Ratio of Plant Biomass or Plant Extract to Metal Concentration

Nanoparticles may only be produced if the precursor concentration is within a sufficient nucleation range. However, the availability of reducing and capping agents determines whether these metal precursors should be reduced and ultimately contributes to the formation of nanoparticles. The concentration of plant extract is directly linked to the density of the electron and the loading groups influence the resulting shapes and sizes of nanoparticles. As indicated by the scientists, the free electrons of this metal cluster would be decreased in small amounts and the surface load of the metal clusters increased [96].

3. Conclusion

Nanotechnology is vital to protect the environment while still supplying enough energy for a growing planet. Advanced nanotechnology techniques help store energy, convert it into other forms and make materials environmentally friendly. In solar technology, nano-catalysis, fuel cells and hydrogen technology, nanotechnology has been used for cheaper energy production and renewal energies. In current work, biosynthesis of AgO nanoparticles was carried out in accordance with the aims and scope of green chemistry. The biological method is environmental friendly, low cost and no extra instruments required to synthesize metallic oxide nanoparticles. The synthesis of AgO NPs can confirmed by color change in solution visually. FTIR confirm the presence of biomolecules that are responsible for the capping and reduction of Ag+ ions to AgO nanoparticles. The lattice plane, crystallinity and average particle size was determined by XRD. The SEM micrograph indicate the spherical shaped AgO nanoparticles with average crystal size The elemental analysis depicts the purity of AgO nanoparticles with the strong peaks of AgO nanoparticles. EDX reveal the atomic weight and atomic percentage of elements present in the sample. AgO nanoparticles have various application as antifungal and antibacterial agent. The biosynthesized AgO NPs were studied against the five different pathogens that showed an excellent antifungal potential. Increasing surface area and nano-scale effects are used as nano materials as a promising instrument for the development of drug, gene and biomedical imaging, diagnostic biosensors. In contrast to their larger counterparts, nano particles have distinct physicochemical and biological properties. The biosynthesized nanoparticles can be used in various pharmaceutical industries.

References

[1] Karimi-Maleh, H., P. Biparva, and M. Hatami, A novel modified carbon paste electrode based on NiO/CNTs nanocomposite and (9, 10-dihydro-9, 10-ethanoanthracene-11, 12-dicarboximido)-4-ethylbenzene-1, 2-diol as a mediator for simultaneous determination of cysteamine, nicotinamide adenine dinucleotide and folic acid. Biosensors and Bioelectronics, 2013. 48: p. 270-275.

[2] Ghaffari-Moghaddam, M. and R. Hadi-Dabanlou, Plant mediated green synthesis and antibacterial activity of silver nanoparticles using Crataegus douglasii fruit extract. Journal of Industrial and Engineering Chemistry, 2014. 20 (2): p. 739-744.

[3] Elechiguerra, J. L., et al., Interaction of silver nanoparticles with HIV-1. Journal of nanobiotechnology, 2005. 3 (1): p. 6.

[4] Mohan, S., et al., Completely green synthesis of dextrose reduced silver nanoparticles, its antimicrobial and sensing properties. Carbohydrate polymers, 2014. 106: p. 469-474.

[5] Tabasi, S., H. Hassani, and A. Azadmehr, Phytoextraction-based process of metal absorption from soil in mining areas (tailing dams) by Medicago sativa L.(Alfalfa) (Case study: Sarcheshmeh porphyry copper mine, SE of Iran). Journal of Mining & Environment, 2017. 8 (3): p. 419-431.

[6] Flanagan, K., E. Uyarra, and M. Laranja, Reconceptualising the 'policy mix'for innovation. Research policy, 2011. 40 (5): p. 702-713.

[7] Begum, N. A., et al., Biogenic synthesis of Au and Ag nanoparticles using aqueous solutions of Black Tea leaf extracts. Colloids and surfaces B: Biointerfaces, 2009. 71 (1): p. 113-118.

[8] Bender, T., et al., Evidence-based hydro-and balneotherapy in Hungary—a systematic review and meta-analysis. International journal of biometeorology, 2014. 58 (3): p. 311-323.

[9] He, K., et al. Deep residual learning for image recognition. in Proceedings of the IEEE conference on computer vision and pattern recognition. 2016.

[10] Love, S. A., et al., Assessing nanoparticle toxicity. Annual review of analytical chemistry, 2012. 5: p. 181-205.

[11] Krutyakov, Y. A., et al., Synthesis and properties of silver nanoparticles: advances and prospects. Russian Chemical Reviews, 2008. 77 (3): p. 233-257.

[12] Monteiro, D. R., et al., The growing importance of materials that prevent microbial adhesion: antimicrobial effect of medical devices containing silver. International journal of antimicrobial agents, 2009. 34 (2): p. 103-110.

[13] Ahamed, M., M. S. AlSalhi, and M. Siddiqui, Silver nanoparticle applications and human health. Clinica chimica acta, 2010. 411 (23-24): p. 1841-1848.

[14] Dallas, P., V. K. Sharma, and R. Zboril, Silver polymeric nanocomposites as advanced antimicrobial agents: classification, synthetic paths, applications, and perspectives. Advances in colloid and interface science, 2011. 166 (1-2): p. 119-135.

[15] Su, J., et al., Exploring feasibility of multicolored CdTe quantum dots for in vitro and in vivo fluorescent imaging. Journal of nanoscience and nanotechnology, 2008. 8 (3): p. 1174-1177.

[16] Tolaymat, T. M., et al., An evidence-based environmental perspective of manufactured silver nanoparticle in syntheses and applications: a systematic review and critical appraisal of peer-reviewed scientific papers. Science of the Total Environment, 2010. 408 (5): p. 999-1006.

[17] Ravindran, A., P. Chandran, and S. S. Khan, Biofunctionalized silver nanoparticles: advances and prospects. Colloids and Surfaces B: Biointerfaces, 2013. 105: p. 342-352.

[18] Srimal, R. and B. Dhawan, Pharmacology of diferuloyl methane (curcumin), a non-steroidal anti-inflammatory agent. Journal of pharmacy and pharmacology, 1973. 25 (6): p. 447-452.

[19] Prasad, S. and B. B. Aggarwal, Turmeric, the golden spice. Herbal Medicine: Biomolecular and Clinical Aspects. 2nd edition, 2011.

[20] Rajagopal, K., et al., Activity of phytochemical constituents of Curcuma longa (turmeric) and Andrographis paniculata against coronavirus (COVID-19): an in silico approach. Future journal of pharmaceutical sciences, 2020. 6 (1): p. 1-10.

[21] Sathishkumar, M., K. Sneha, and Y.-S. Yun, Immobilization of silver nanoparticles synthesized using Curcuma longa tuber powder and extract on cotton cloth for bactericidal activity. Bioresource technology, 2010. 101 (20): p. 7958-7965.

[22] Rajesh, H., et al., Phytochemical analysis of methanolic extract of Curcuma longa Linn rhizome. International Journal of Universal Pharmacy and Bio Sciences, 2013. 2 (2): p. 39-45.

[23] Shenashen, M. A., S. A. El-Safty, and E. A. Elshehy, Synthesis, morphological control, and properties of silver nanoparticles in potential applications. Particle & Particle Systems Characterization, 2014. 31 (3): p. 293-316.

[24] Lee, S. K. and A. Mills, Novel photochemistry of leuco-Methylene Blue. Chemical Communications, 2003 (18): p. 2366-2367.

[25] Singh, M. K. and M. S. Mehata, Enhanced photoinduced catalytic activity of transition metal ions incorporated TiO_2 nanoparticles for degradation of organic dye: Absorption and photoluminescence spectroscopy. Optical Materials, 2020. 109: p. 110309.

[26] Mahlaule-Glory, L., et al., Biological therapeutics of AgO nanoparticles against pathogenic bacteria and A549 lung cancer cells. Materials Research Express, 2019. 6 (10): p. 105402.

[27] Husen, A. and K. S. Siddiqi, Phytosynthesis of nanoparticles: concept, controversy and application. Nanoscale research letters, 2014. 9 (1): p. 229.

[28] Marcovich, A. and T. Shinn, Socio/intellectual patterns in nanoscale research: Feynman Nanotechnology Prize laureates, 1993—2007. Social Science Information, 2010. 49 (4): p. 615-638.

[29] Williams, D., The relationship between biomaterials and nanotechnology. 2008, Elsevier.

[30] Sivaguru, P. and X. Bi, Introduction to Silver Chemistry. Silver Catalysis in Organic Synthesis, 2019: p. 1-32.

[31] Zeng, S., et al., Nanomaterials enhanced surface plasmon resonance for biological and chemical sensing applications. Chemical Society Reviews, 2014. 43 (10): p. 3426-3452.

[32] Jeevanandam, J., et al., Review on nanoparticles and nanostructured materials: history, sources, toxicity and regulations. Beilstein journal of nanotechnology, 2018. 9 (1): p. 1050-1074.

[33] Tran, Q. H. and A.-T. Le, Silver nanoparticles: synthesis, properties, toxicology, applications and perspectives. Advances in Natural Sciences: Nanoscience and Nanotechnology, 2013. 4 (3): p. 033001.

[34] Ochekpe, N. A., P. O. Olorunfemi, and N. C. Ngwuluka, Nanotechnology and drug delivery part 1: background and applications. Tropical Journal of Pharmaceutical Research, 2009. 8 (3).

[35] Reidy, B., et al., Mechanisms of silver nanoparticle release, transformation and toxicity: a critical review of current knowledge and recommendations for future studies and applications. Materials, 2013. 6 (6): p. 2295-2350.

[36] Michel, J.-B., et al., Quantitative analysis of culture using millions of digitized books. science, 2011. 331 (6014): p. 176-182.

[37] Damschroder, L. J., et al., Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implementation science, 2009. 4 (1): p. 50.

[38] McGillicuddy, E., et al., Silver nanoparticles in the environment: Sources, detection and ecotoxicology. Science of the Total Environment, 2017. 575: p. 231-246.

[39] Yadav, T P., R. M. Yadav, and D. P. Singh, Mechanical milling: a top down approach for the synthesis of nanomaterials and nanocomposites. Nanoscience and Nanotechnology, 2012. 2 (3): p. 22-48.

[40] Saravanan, P., R. Gopalan, and V. Chandrasekaran, Synthesis and Characterisation of Nanomaterials. Defence Science Journal, 2008. 58 (4).

[41] Goutam, S. P., et al., Green synthesis of nanoparticles and their applications in water and wastewater treatment, in Bioremediation of Industrial Waste for Environmental Safety. 2020, Springer. p. 349-379.

[42] Westwood, W. D., Sputter Deposition. AVS Education Committee book series. Vol. 2. 2003.

[43] Ichinose, N., Y. Ozaki, and S. Kashu, Superfine particle technology. 2012: Springer Science & Business Media.

[44] Ibarra-Arán, J.-C., et al., In vitro evaluation of bactericidal effect of silver and gold-silver nanoparticles coated with silicon dioxide on Xanthomonas fragariae. MRS Advances, 2017. 2 (49): p. 2683-2688.

[45] Thiagarajan, S., A. Sanmugam, and D. Vikraman, Facile methodology of sol-gel synthesis for metal oxide nanostructures. Recent Applications in Sol-Gel Synthesis, 2017: p. 1-17.

[46] Pudovkin, M. S., et al., Coprecipitation method of synthesis, characterization, and cytotoxicity of Pr^{3+}: LaF3 (CPr= 3, 7, 12, 20, 30%) nanoparticles. Journal of nanotechnology, 2018. 2018.

[47] Rane, A. V., et al., Methods for synthesis of nanoparticles and fabrication of nanocomposites, in Synthesis of inorganic nanomaterials. 2018, Elsevier. p. 121-139.

[48] Badawy, M. E., T. M. Lotfy, and S. M. Shawir, Preparation and antibacterial activity of chitosan-silver nanoparticles for application in preservation of minced meat. Bulletin of the National Research Centre, 2019. 43 (1): p. 83.

[49] Sharma, D., S. Kanchi, and K. Bisetty, Biogenic synthesis of nanoparticles: A review. Arabian Journal of Chemistry. press, http://dx.doi.org/10.1016/j.Arabjc,2015.2.

[50] Khan, I., K. Saeed, and I. Khan, Nanoparticles: Properties, applications and toxicities. Arabian journal of chemistry, 2019. 12 (7): p. 908-931.

[51] Goutam, S. P., et al., Green synthesis of TiO_2 nanoparticles using leaf extract of Jatropha curcas L. for photocatalytic degradation of tannery wastewater. Chemical Engineering Journal, 2018. 336: p. 386-396.

[52] Das, A., et al., Sunlight irradiation induced synthesis of silver nanoparticles using glycolipid bio-surfactant and exploring the antibacterial activity. J Bioeng Biomed Sci, 2016. 6 (05).

[53] Umoren, S., I. Obot, and Z. Gasem, Green Synthesis and Characterization of Silver Nanoparticles Using Red Apple (Malus domestica) Fruit Extract at Room Temperature. 2014. 5: p. 907-914.

[54] Bhakya, S., et al., Biogenic synthesis of silver nanoparticles and their antioxidant and antibacterial activity. Applied Nanoscience, 2016. 6 (5): p. 755-766.

[55] Arokiyaraj, S., et al., Green synthesis of silver nanoparticles using Rheum palmatum root extract and their antibacterial activity against Staphylococcus aureus and Pseudomonas aeruginosa. Artificial cells, nanomedicine, and biotechnology, 2017. 45 (2): p. 372-379.

[56] Steinfeld, B., et al., The role of lean process improvement in implementation of evidence-based practices in behavioral health care. The Journal of Behavioral Health Services & Research, 2015. 42 (4): p. 504-518.

[57] Ibrahim, H. M., Green synthesis and characterization of silver nanoparticles using banana peel extract and their antimicrobial activity against representative microorganisms. Journal of Radiation Research and Applied Sciences, 2015. 8 (3): p. 265-275.

[58] Ali, K., et al., Microwave accelerated green synthesis of stable silver nanoparticles with Eucalyptus globulus leaf extract and their antibacterial and antibiofilm activity on clinical isolates. PloS one, 2015. 10 (7): p. e0131178.

[59] Kemp, K., et al., An exploration of the follow-up up needs of patients with inflammatory bowel disease. Journal of Crohn's and Colitis, 2013. 7 (9): p. e386-e395.

[60] Satyavani, K., et al., Biomedical potential of silver nanoparticles synthesized from calli cells of Citrullus colocynthis (L.) Schrad. Journal of nanobiotechnology, 2011. 9 (1): p. 43.

[61] Sankar, R., et al., Facile synthesis of Curcuma longa tuber powder engineered metal nanoparticles for bioimaging applications. Journal of Molecular Structure, 2017. 1129: p. 8-16.

[62] Kundu, S. and U. Nithiyanantham, In situ formation of curcumin stabilized shape-selective Ag nanostructures in aqueous solution and their pronounced SERS activity. Rsc Advances, 2013. 3 (47): p. 25278-25290.

[63] Patra, S., et al., Green synthesis, characterization of gold and silver nanoparticles and their potential application for cancer therapeutics. Materials Science and Engineering: C, 2015. 53: p. 298-309.

[64] Shukla, P. K., P. Misra, and C. Kole, Uptake, translocation, accumulation, transformation, and generational transmission of nanoparticles in plants, in Plant Nanotechnology. 2016, Springer. p. 183-218.

[65] Mohanpuria, P., N. K. Rana, and S. K. Yadav, Biosynthesis of nanoparticles: technological concepts and future applications. Journal of nanoparticle research, 2008. 10 (3): p. 507-517.

[66] Thomas, R., et al., Evaluation of antibacterial activity of silver nanoparticles synthesized by a novel strain of marine Pseudomonas sp. Nano Biomedicine and Engineering, 2012. 4: p. 139-143.

[67] Asha, K., et al., Extracellular synthesis of silver nanoparticles from A marine Alga, Sargassum polycystum C. agardh and their biopotentials. WJPPS, 2015. 4: p. 1388-1400.

[68] Goudarzi, M., et al., Biosynthesis and characterization of silver nanoparticles prepared from two novel natural precursors by facile thermal decomposition methods. Scientific reports, 2016. 6: p. 32539.

[69] Velgosová, O., A. Mražíková, and R. Marcinčáková, Influence of pH on green synthesis of Ag nanoparticles. Materials letters, 2016. 180: p. 336-339.

[70] Mori, K., et al., A pH-induced size controlled deposition of colloidal Ag nanoparticles on alumina support for catalytic application. The Journal of Physical Chemistry C, 2009. 113 (39): p. 16850-16854.

[71] Anigol, L. B., J. S. Charantimath, and P. M. Gurubasavaraj, Effect of concentration and ph on the size of silver nanoparticles synthesized by green chemistry. Org. Med. Chem. Int. J, 2017. 3: p. 1-5.

[72] Salama, H. M., Effects of silver nanoparticles in some crop plants, common bean (Phaseolus vulgaris L.) and corn (Zea mays L.). Int Res J Biotechnol, 2012. 3 (10): p. 190-197.

[73] Xu, R., Wang, D., Zhang, J., and Li, Y. (2006). Shape-dependent catalytic activity of silver nanoparticles for the oxidation of styrene. Chem. Asian J. 1, 888–893. Doi: 10.1002/asia.200600260.

[74] Whiteley, C. M., Dalla Valle, M., Jones, K. C., and Sweetman, A. J. (2013). Challenges in assessing release, exposure and fate of silver nanoparticles within the UK environment. Environ. Sci. Process. Impact 15, 2050–2058. Doi: 10.1039/c3em00226h.

[75] Mughal, S., et al., *Role of Silver Nanoparticles in Colorimetric Detection of Biomolecules.* 2019.

[76] Perveiz, S., et al., *A Review on Heavy metal contamination in water and the Strategies for the Reduction of Pollution Load of Commercial and Industrial Areas of Pakistan.*

[77] Hafeez, M., et al., *Evaluation of Biological Characteristics of Abelmoschus esculentus.*

[78] Hanif, M. A., et al., *An overview on ajwain (Trachyspermum Ammi) pharmacological effects: current and conventional.* Technology, 2021. *5* (1): p. 1-6.

[79] Rafique, S., et al., *A review on potential antioxidant effects of Cumin (Cuminum cyminum), phytochemical Profile and its uses.* 2020. *8*: p. 2020.

[80] Rafique, S., et al., *Biological attributes of lemon: A review.* Journal of Addiction Medicine and Therapeutic Science, 2020. *6* (1): p. 030-034.

[81] Mubeen, N., et al., *Vitality and Implication of Natural Products from Moringa oleifera: An Eco-Friendly Approach.* Computational Biology and Bioinformatics, 2020. *8* (2): p. 72.

[82] Abbas, F., et al., *Synthesis and Characterization of Silver Nanoparticles Against Two Stored Commodity Insect Pests.*

[83] Aslam, A., et al., *Comprehensive Review of Structural Components of Salvia hispanica & Its Biological Applications.* International Journal of Biochemistry, Biophysics & Molecular Biology, 2020. *5* (1): p. 1.

[84] Sarfraz, S., et al., *Copper Oxide Nanoparticles: Reactive Oxygen Species Generation and Biomedical Applications.* Int. J. Comput. Theor. Chem, 2020. *8*: p. 40-46.

[85] Khalid, Z., et al., *Phenolic Profile and Biological Properties of Momordica charantia.* Chemical and Biomolecular Engineering, 2021. *6* (1): p. 17.

[86] Tahir, M. U., et al., *SYNTHESIS OF MANGANESE-TIN BIMETALLIC MATERIALS AND STUDY OF ITS CATALYTIC APPLICATIONS.*

[87] Hassan, S. M., et al., *Cellular interactions, metabolism, assessment and control of aflatoxins: an update.* Comput Biol Bioinform, 2020. *8*: p. 62-71.

[88] ul Mustafa, Z., et al., *Edge Functionalization of Phosphorene with different Chemical Functional Groups.*

[89] Khattak, A. K., M. Syeda, and S. Shahzad, *General overview of phytochemistry and pharmacological potential of Rheum palmatum (Chinese rhubarb).* Innovare Journal of Ayurvedic Sciences, 2020. *8* (6): p. 1-5.

[90] Latif, M. J., et al., *Therapeutic potential of Azadirachta indica (neem) and their active phytoconstituents against diseases prevention.* J. Chem Cheml Sci., 2020. *10* (3): p. 98-110.

[91] Khalid, Z., et al., *A review on biological attributes of Momordica charantia.* Adv Biosci Bioeng, 2021. *9* (1): p. 8-12.

[92] Afzal, N., et al., *Control of Aflatoxins in Poultry Feed by Using Yeast.* American Journal of Chemical and Biochemical Engineering, 2022. *6* (1): p. 21-26.

[93] Shabbir, N., et al., *Eletteria cardamomum and Greenly Synthesized MgO NPs: A Detailed Review of Their Properties and Applications.* Engineering Science, 2022. *7* (1): p. 15-22.

[94] Mubeen, N., S. M. Hassan, and S. S. Mughal, *A Biological Approach to Control Aflatoxins by Moringa Oleifera.* International Journal of Bioorganic Chemistry, 2020. *5* (2): p. 21.

[95] Hafeez, M., et al., *Antioxidant, Antimicrobial and Cytotoxic Potential of Abelmoschus esculentus.* Chemical and Biomolecular Engineering, 2020. *5* (4): p. 69.

[96] Muneer, M., et al., *diagnosis and treatment of diseases by using metallic nanoparticles- a review.* 2020.