

A Systematic Review Of Metallic Nanoparticles: Synthesis, Biological Activities & Applications

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Abstract

Metallic nanoparticles (MNP) have captivated scientist for over a century and are now profoundly utilized in biomedical sciences and engineering. MNPs interact with key cellular organelles and biomolecules, including DNA, enzymes, ribosomes, and liposomes, which can have an impact on gene expression, oxidative stress, protein and enzyme activation, and cell membrane permeability. It has been shown that the cellular metabolites of living organisms like bacteria, yeast, fungi, and plant cells can convert inorganic metal ions into metal NPs. By utilizing biological agents in green chemistry, metallic nanoparticles are produced that have less adverse effects and are more effective against cancer cells. These nanoparticles can physically infiltrate cancer cells and kill them by activating a variety of biochemical pathways, including apoptosis, necrosis, and autophagy. This review focuses on metal nanoparticles (copper, gold, and silver) and their usefulness in treating endemic diseases including cancer, hepatitis, and malaria. In the near future, metal NPs may also be a successful and affordable alternative for treating drug-resistant bacterial infections.

Keywords: Metallic Nanoparticles, Green Chemistry, Necrosis

INTRODUCTION

A successful answer to the major problem of bacterial antibiotic resistance has been offered via nanotechnology. Physical and chemical techniques can be used to prepare and stabilise NPs.¹ Toxic chemicals are utilised in chemical synthesis, which results in unfriendly byproducts.² This is why using non-toxic, environmentally friendly methods to synthesise NPs is necessary.³ It has been suggested to apply biological techniques to safeguard the environment.⁴ The development of environmental friendly NP synthesis with using biological components such as microbes or plant extracts using plant extracts The molecules used in the quick, healthy, non-pathogenic, and affordable assembly of metallic nanoparticles (NPs) are molecules⁵ Combining biomolecules with medicinal properties, including Metallic ions can be reduced and stabilized by enzymes, polysaccharides, tannins, phenolics, saponins, and terpenoids⁶. Ecological nanoparticle synthesis has additionally been enhanced to produce new materials that are durable, pricey, and ecologically beneficial. Bark extracts are great bio reductants in this situation⁷. This is primarily because they include phenolic chemicals, which can be used to create NPs with precise control over size and form as well as improved stability and biocompatibility⁸. To explore the characteristics of metallic nanoparticles mediated by plant bark extracts and their properties, such as anticancer, antimicrobial, antioxidant, and other activity⁹. The search terms were: metallic nanoparticles bark extract, woody vascular plants, phytoconstituents, reducing agents, antioxidants, antimicrobial, and anticancer¹⁰. Have discovered how to manufacture NPs from their individual salt precursors and stable them in solution using living things and biomaterials¹¹. Whereby greener strategies use eco-friendly and natural ingredients rather than pricy and hazardous chemicals. The Earth's atmosphere has been severely damaged by rapid industrialization, urbanization, and population growth, which has added dangerous compounds to the environment. The approach for NPs is a good alternative to the physical and chemical procedures¹². where earth-abundant living creatures can be used to manufacture metal NPs (MNPs) and metal oxide NPs, also including plants, bacteria, fungi, algae, yeasts, and lichens (MONPs) Due to the fact that MNPs and MONPs are produced using metal precursors, this process is considered a bottom-up approach. This study discusses the antibacterial and anticancer properties of photosynthesized and phytomodified MNPs/MONPs as well as current advancements and associated difficulties¹³. Following a discussion on related photosynthetic mechanisms and an interpretation of the antibacterial and anticancer actions for MNPs/MONPs, various chemical and physical approaches are first offered for the preliminary knowledge of reproducible protocols Interesting properties can be found in metallic nanoparticles (NPs).¹⁴ They have distinctive optical, thermal, magnetic, and redox properties and are typically spherical in shape. They are made of entirely or mostly of one or more metal or metal oxides¹⁵. Numerous applications exist

including sensors, bactericidal goods, nanomedicine, optics, and electronics, as well as catalysis. Furthermore, it has been claimed that the size of NPs (smaller than cells) closely correlates with their toxicity. One on each hand, toxicity related to NPs continues to be a problem. Size and form of AgNPs are crucial elements that directly affect the particles' ability to kill bacteria. Be aware that the bactericidal effect depends on concentration. Aside from that adsorbents. In this regard, the OECD has concentrated on nanoparticles of high economic value, such as silver and gold NPs (AuNPs) as well as AgNPs, including both), as sources of information for research involving safety, risk, and toxicology assessments, and organelles] which enables each other to penetrate in to the biological systems altering cellular function. They can be absorbed by the skin, ingestion, or inhalation.¹⁶ Cardiovascular disorders and the formation of reactive oxygen species are only a few of the reported negative effects (ROS) AgNPs' capacity to transfer silver ions (Ag), which are antibacterial agents in aerobic circumstances and in aqueous matrices, is affected by size and NP capping.¹⁷ As a result, it is necessary to characterize and determine these NP characteristics in order to govern them appropriately. Numerous analytical techniques have been suggested recently to describe and measure metal Nanoparticles and their dispersions.¹⁸ Though still in its infancy, phyconanotechnology has recently emerged as a promising field with expanded potential for the synthesis of NPs made from algae.¹⁹ The biggest group of photoautotrophic microorganisms, algae, has the ability to produce a wide range of secondary metabolites, pigments and proteins that can be utilized as Nanoparticles²⁰. Bio factory for metallic nanoparticles. Simple techniques have been devised, including the reduction of the metal ions extra cellular or intracellular. By biological extracts, alkaloids etc.²¹ present in the extracts, which assists in metal reduction and their stabilization. Metallic precursors to their equivalent NPs have been successfully converted by extracts from plants, fungus, human cells, and diatoms. Algae are a cheap source of raw materials due to their high metal absorption capacity and prevalence.²² of the NPs. A variety of substances, including bioactive constituents, polyphenolic compounds, flavonoids, amines, amides, proteins, and pigments, have made it easier to synthesize these NPs.²³ The wide range of uses and resistance to harsh circumstances are justified by their. The contact and biochemical processes that occur between each microorganism, as well as internal variables like pH and temperature ultimately have a major impact on the diameter & morphology considerable volume to surface area ratio. Due to their wide range of uses in fields like medicine, industry, electronics, sensors, cosmetics, pharmaceuticals, agriculture, and bioremediation, their synthesis is essential. The work on the biosynthetic pathways synthesis gold (Au), silver (Ag), palladium (Pd), platinum (Pt), iron (Fe), cadmium (Cd), titanium oxide (TiO₂), zinc oxide (ZnO),²⁴

Classification of metallic nanoparticles

A vast variety of NPs can be created artificially or found naturally in the environment; the latter is frequently referred to as anthropogenic NPs.²⁵ Natural NPs are present in living things, but from the earth's creation, their existence has been presumed in the biosphere.²⁶ Wild fires, volcanic eruptions, rock weathering, clay mineral explosions, soils erosions, and sandstorms can all produce natural NPs. As a result of forest fires, volcanic, weathering explosions and clay minerals, soil erosion, and sandstorms, NPs are divided into many categories based on shape, dimension, phase composition, and material type²⁷. Based on their size, shape, phase composition, and kind of material, NPs are divided into various groups' composition,

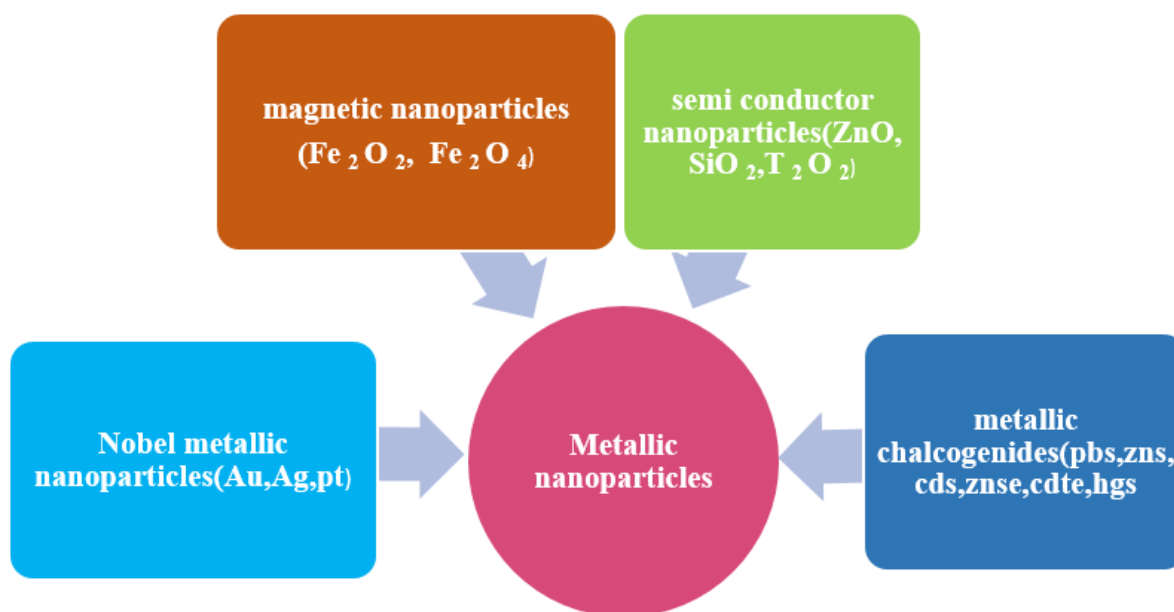


Figure 1: Antimicrobial activities of different metallic NPS

Antimicrobial activity of Ag NPs

Despite the fact that antibiotics are frequently utilised in the medical industry, the bacteria can get resistant with time. Since ancient times, silver has been utilised extensively as an antibacterial agent.²⁸ It is currently used as a strong

antibacterial agent for treating wounds. This could be the outcome of a self-defensive strategy used by bacteria, which could lead to gene mutation²⁹. This makes it easier for antibiotic-inactivating enzymes to develop Antibiotic bacterial resistance has so grown to be a serious problem. Scientists have described a number of novel strategies to address this problem, one of which is the antibacterial activity of NPs.³⁰ Silver is the most effective antibacterial agent among the other NPs. Additionally, Ag NPs are utilised as nano-drug and nano-antibiotic carriers, which aid in boosting of the antibiotic's efficacy against resistant bacteria.³¹ Ag NPs' antibacterial effectiveness is influenced by their size and form. According to when Ag NPs get smaller, their surface area grows, which improves their ability to bind to molecules.³² Additionally, a triangular-shaped Ag NP shown substantially stronger antibacterial action than a spherical or rod-shaped one. Ag NPs produce reactive oxygen species (ROS), which are in charge of oxidizing biological components like protein and DNA.³³ These components oxidize, making cells physiologically and genetically unstable and impairing cell division and metabolism.³⁴

Antimicrobial activity of Fe NPs

Biogenic iron which is nanoscale has also been shown to be an effective antimicrobial, similar to Ag and Au NPs.³⁵ The 80–100 nm moderately bioactive nanoparticles of iron oxide (Fe NPs) made from T. part of service leaf extract showed bactericidal activity against *P. aeruginosa*, a Gram-negative bacterium reported the generation of Fe NPs mediated by *G. jasminoides* and *L. interims* extract and investigated their inhibitory activity against *S. aureus*, *S. enteric*, *P. mirabilis*, and *E. coli*.³⁶ The tested microbial growth was successfully suppressed by both NPs. *Skimmia aureole* extract was recently employed to create poly-dispersed Fe NPs that shown outstanding antibacterial activity against the ecological pathogenic *R. solanacearum* through cell wall breakdown. Fe NPs made from *M. oleifera* leaf extract shown antibacterial efficacy against *P. aeruginosa*, *E. coli*, *S. aureus*, *S. typhi*, and *P. multocida* in a separate Endeavour. Employed Skimmed aureole extract to create poly-dispersed.

Bactericidal properties of zinc oxide NPs

Antibiotic resistance and the global resurgence of bacterial diseases pose a grave threat to human life.³⁷ Nowadays, a lot of research is being done on zinc dioxide nanoparticles (ZnO NPs) because of its special antibacterial and antifungal capabilities³⁸. ZnO is thought to be biocide and has been shown to have photo-oxidizing and photo catalytic effects. It has been discovered that ZnO NPs are efficient against bacteria with sizes between nanometers to micrometers³⁹. ZnO can interact with bacterial cells more easily by penetrating into them because of its nanoscale size. ZnO nanoparticle's unique physico-chemical characteristics including a high surface area to volume ratio are primarily responsible for their antibacterial effects⁴⁰. Researchers are currently thoroughly examining ZnO NPs as multiple studies have shown that they are biodegradable in human cells.⁴¹ It is well known that cell surface proteins on pathogenic bacteria aid in colony formation and adherence. The cell wall also contains polysaccharides and tiechoic acid, which shield the organism from the host's defines and the outside environment.⁴² All of them are charged macromolecules; therefore using the surface-modified NPs can be employed to create particular interactions that will cause the integrity to be disrupted. Both Gram-positive and Gram-negative bacteria can be effectively killed by ZnO⁴³ Recently revealed that ZnO NPs have greater antibacterial activities on *S. aureus* than MgO, TiO₂, Al₂O₃, CuO, and CeO₂.

Bactericidal properties of Au NPs

The biocompatibility and antibacterial activity of Au NPs are well recognized.⁴⁴ To have an effective antibacterial property, Au NPs must have been linked with other bimolecular because they are unable to operate alone on the target.⁴⁵ According to cross-linking collagen, chitosan, and gelatin with au NPs makes it simple to connect with the macromolecules. Incorporating Au NPs with additional medicinal molecules can result in a synergistic antibacterial action.⁴⁶ Antimicrobials conjugated Au NPs were shown to have an impact on *E. coli* and vancomycin-resistant enterococci (VRE) by Vancomycin were reported to have a 50-fold greater antibacterial action.⁴⁷ The antibacterial activity of Au NPs can also be increased by conjugating them with pathogen-specific antibodies or photosensitizing compounds enabling photo thermal and photodynamic therapy.⁴⁸ Various actions taken by Au NPs on bacterial cells can be seen. It might infiltrate cells and change the membrane potential by preventing ATP synthesis from working. It causes ATP levels to drop, which collapses overall energy Metabolism and causes cell death this non-ROS dependent mechanism also kills multidrug resistant (MDR) microorganisms.⁴⁹ Claims that multiagency onto NPs are made possible by the high surface-to-volume ratio, allowing for the incorporation of several functional ligands. The interaction of the NP surface with the target bacterium can be improved by this multiagency. These characteristics make it possible to use NPs with antibiotics to treat bacterial multidrug resistance.⁵⁰

Bactericidal activity of other metals

Tellurium, cerium, tellurium, and biogenic palladium NPs have all demonstrated antibacterial action⁵¹. A paper claims that *M. oleifera* peel methanol extract was utilised to make Pd NPs and was employed for its antibacterial properties towards *E. coli* and *Staphylococcus aureus*.⁵² The results of the antimicrobial assay demonstrated that the NPs successfully slowed down overall development both of bacterial strains. The activity of the CeO₂ NPs against the aforementioned bacterial strains was observed by the same group when they biologically produced them form *Oleifera* peel extract.⁵³ The effectiveness of both strains' inhibition was confirmed by an antibacterial assay. Another amniotic

study describes that micro of Cu₂O from leaf extract and discusses how they might be used to combat various Gram-positive and Gram-negative bacteria.⁵⁴

Properties of metal NPs

In contrast to the solid, stable metal atoms found in bulk, the metal NPs exhibit rare physicochemical, optical, and thermal properties due to their high proportion of high-energy freely accessible surface atoms⁵⁵. Metal nanoparticles are specifically used in biomedicine, diagnostic tests, drug/gene delivery, and radiation enhancement. Metal NPs have particular traits that include: reduced toxicity compared to atomic level at the nanoscale.⁵⁶ Metal NPs' optical characteristics are improved by surface-Plasmon resonance in the UV-Visible range as a result of the greater availability of electrons during the conduction band ability to generate heat from light or radio frequencies, allowing for photo thermal.⁵⁷ As a result, metals have physicochemical characteristics just at nanoscale that help in the creation and application of several tools based on nanotechnology that promote scientific study.

SYNTHESIS OF METAL NANOPARTICLES

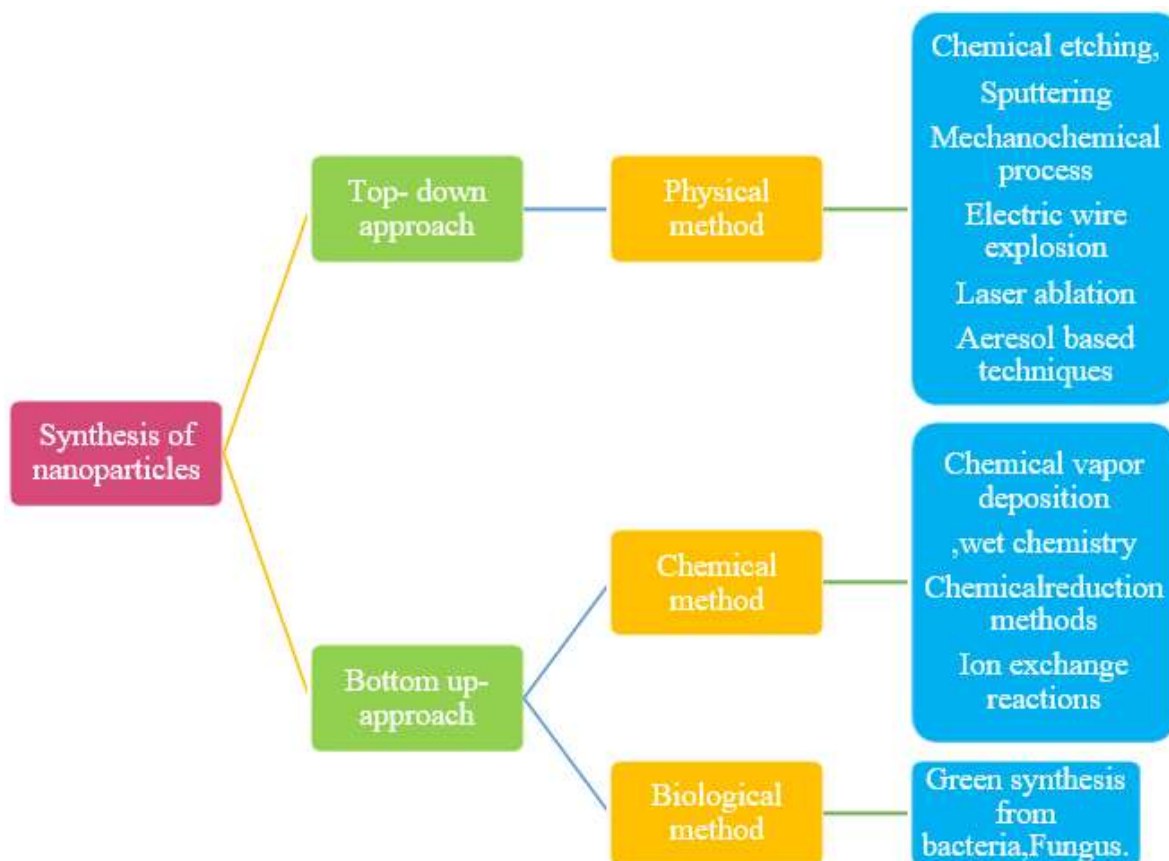


Figure 2: Methods of Synthesis of Metallic Nanoparticles

BIOLOGICAL METHODS

Plant assisted synthesis

When compared to microbial synthesis, plants assisted NP synthesis is more effective in terms of yield. Numerous biochemical's and metabolites found in plants, such as polyphenols, can act as reducing and stabilizing agents with in production of biogenic NPs⁵⁸. which are more stable than those made by fungus and bacteria. NPs are synthesized by plants.⁵⁹ Plant-mediated NP synthesis is both cost-effective and environmentally benign because hazardous chemicals are not used. It was discovered that NPs from plant sources were significantly⁶⁰

Bacteria assisted synthesis of NPs

There are two methods for bacterial assistance in the creation of NPs: external and intracellular methods.⁶¹ Cell surface synthesis of NPs is quicker than intracellular synthesis because no additional steps are .required to collect the NPs from the organisms after extracellular synthesis Reductive', an enzyme found inside the cells of bacteria, catalyses the conversion between metal cations into metal NPs.⁶² A bacterial species called D. Radiodurans seems to be naturally resistant to radioactivity and oxidative stress and exhibits high antioxidant activity it makes it advantageous for usage in environmentally friendly Au NP production from its ionic state. The manufactured Au NPs had better antibacterial action and were more stable over time.⁶³

Fungi assisted synthesis of NPs

Organic compounds as well as bioactive bimolecular that are crucial for the synthesis of NPs can be found in abundance in fungi.⁶⁴ Nanoparticles utilizing external amino acid residues. For instance, the surface of yeast contains carboxyl group and aspartic acid, which, in the presence of sufficient light, photo reduce silver. The secretion of proteins, polymers, and enzymes by some fungi, such as *F. Oxysporum*, voluntarily aids in the production of metal NPs the yields & stability of NPs are enhanced by these components.⁶⁵ In earlier studies, it was discovered that a number of fungi species may produce nitrate into silver metal. According to the cytoplasm of fungi like *Fusarium oxysporum* has a reductive enzyme that converts metallic ions to silver metal when NADH present.⁶⁶

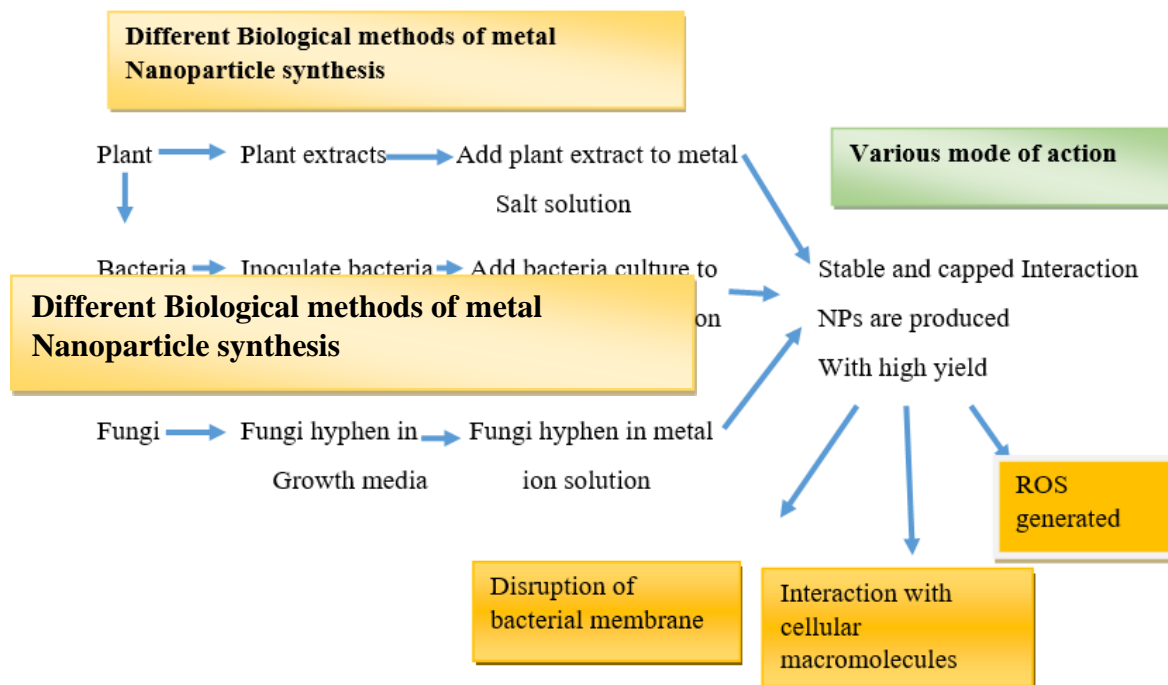


Figure 3: Various Biological Methods for Synthesis of Metallic Nanoparticles

UP TO BOTTOM APPROACH

CHEMICAL ETCHING

Etching, which can be carried out through electrical and chemical arc discharge methods, is one of the frequently used processes.⁶⁷ for removing and transferring components in the creation of NMs and NPs. Chemical etching involves the reaction of chemicals with substrates to produce surface etching.⁶⁸ Voltage, electric current, pulse duration, electrode distance, and deionizer water temperature are the primary variable parameters in the arc discharge process. High-frequency plasma etching is an easy and affordable approach for producing multilayer array of polystyrene nano-spheres with flat surfaces.⁶⁹

SPUTTERING

High-melting point materials are excellent for the thin film deposition method known as sputtering. Under vacuum circumstances, the dispersed atoms form a thin layer also on surfaces of substrates like silicon wafers due to the absence of thermodynamic equilibrium.⁷⁰ The advantages include a regulated procedure at low temperature, size uniformity, and strong catalytic performance for hydrogen evolution reaction. Additionally, Ru NPs of 1.7 nm size are formed on the surface of graphene through sputtering.⁷¹

Mechano chemical process

Using ball-shaped mill in low-temperature chemical reactors, where the grinding balls boost overall kinematic reactions of constituent powders and provide the requisite temp for the reactions by their movements, is an efficient technique to create nanopowders.⁷² Upon heating the bacteria mechano-chemically produced samples at 250 °C, spherical ZnONPs with size have been created. They are more effective against *Campylobacter* and *Escherichia coli* than *Vibrio cholera* and methicillin-resistant⁷³. method can be used to prepare Au, Ag, Pt, Pd, Cu, & Co Nan particle by combining their metal salts with cellulose biopolymer (cry milling technique). MRSA (*Staphylococcus aureus*) In order to reduce metal ions like Ag⁺, Au⁺, Zn²⁺, and Cu²⁺ and stabilize the aggregate data atoms to form MNPs/MONPs, abundant polymer cellulose with a large number of hydroxyl has been employed as a natural renewable source thermo mechanical

Electric wire explosion

Strong electrical pulses within a wire under the pressure of argon gas are used in the electric blasting procedure to produce MNPs and MONPs. This technique calls for a large electrical current to flow quickly via a metal wire that is incredibly

thin. Al NPs and Al/AlN NCs with diameters ranging from 140 nm to 50–60 nm and spherical shapes can be created by electrically igniting aluminum wires while being surrounded by argon (Ar) and nitrogen gases.

Laser ablation

By heating and totally engulfing materials with laser energy relatively low laser current, the process of laser ablation material removal first from surface of a solid. The optical properties of these materials, the laser's wavelength, and the pulse's width all affect how much energy the laser can absorb and how much material it can remove⁷⁴. Laser ablation techniques have been used to create micro/nano designs on polymeric substrates such as polytetrafluoroethylene poly (L-lactic acid), poly (methyl methacrylate), poly (dimethylsiloxane), and medical grade-PVC.⁷⁵

Bottom-up approach

Chemical vapor deposition

The majority of these kinds of preparative protocols are built on the development of small clusters, then aggregation inside this shape of films (condensation). Condensation takes place when the vapors reach super saturation, and homogeneous gas phase nucleation leads to the production of two-dimensional structures called films. The chip (substrate) was exposure within one or more predictor variable, and the required sedimentation is accomplished via reactions or degradation just on substrate surface. Carbon nanotubes (CNTs), carbon nanofibers (CNFs), graphene, diamond, titanium nitride, silicon dioxide, and silicon nitride are just a few examples of the many materials that can be synthesized in amorphous, polycrystalline, epitaxial, and monocrystalline forms at atmosphere.

Wet chemistry

The most popular bottom-up protocols used to synthesize a variety of NMs are wet chemistry techniques. Controlling the size and shape of NPs requires knowledge of surfaces limiting chemicals, and corresponding mechanisms for such converting of such precursor and its interaction to development and nucleation rate. Chemical processes, exchange reactions, and hydrothermal/solvothermal processes.⁷⁶

Chemical reduction methods

The most typical method for making MNPs/MONPs, which are also bulk as room temp in one-pot reaction conditions, involves the reduction of metal salts. This technique can be used to create MNPs made of Ag, Cu, & Gold as well as MONPs made of Titanium dioxide, ZnO, and Fe₃O₄ NPs. In the sections that follow, one key subclasses of a chemical reduction techniques is a greener synthesis approach.⁷⁷

Ion-exchange reactions

Solids are formed first from solutions of metal ions by ion exchange processes. MNPs and MONPs are construct alkaline solution to a acidic metal salt solution, which is then reduced with reducing agents. The precipitation techniques can result in the formation of MNPs and metal-chalcogenide complexes. Due to the distinction in ionic radii, a cation exchanges reaction is more frequent than an anionic reaction. Additionally, different NCs can be prepared using the ion exchange technique, such as highly distributed Nanoparticles on porous ZnO nanoplates. Due to the amorphous substitutions with Al for Mg inside its central alumina plane, montmorillonites, a particularly soft feldspar family mineral materials, have such a high cations exchange capacity. Due to their capacity for intercalation, these plentiful, natural, and reasonably priced clays can be employed to improve the safety features of MNPs and MONPs. In a cation exchange reaction approach, nonmaterial's containing group of population or polypropylene monofilaments can be decorated with Ag, Cu, and ZnO NPs to enhance their biocompatibility, biodegradability, and antibacterial characteristics.⁷⁸

Applications of metallic nanoparticles

Metallic NPs for a variety of uses.

The electric explosion of the two twisted metal wires was used to generate core-shell and Janus nanoparticles (NPs) that contained Cu-Ag, Cu-Pb, and Al-Pb. However, this technique needs very demanding circumstances, which has resulted in its minimal applicability. They have been reported to have antibacterial, anti-cancer, and antifungal properties, making them competitive with conventional medications. The metal nanoparticles have several uses besides medicine, including electronics, Therapeutics, bioremediation, environmental health, optics, coat food packaging, sensing devices, space industries, mechanics, light emitters, nonlinear optical devices, chemical induct, and photo-electrochemical applications. The preparation of the core-shell and Janus NPs, which contain Cu-Ag, Cu-Pb, and Al-Pb, involved an electric explosion of two twisted metal wires. However, the fact that this procedure needs some very difficult circumstances has limited its use. The exploratory application of NPs in biological systems led to the multidisciplinary technique employed to synthesise metallic NPs from several algal sources.

Antimicrobial activity

Because of their propensity to administer medications within the ideal dosage range, NPs are gaining more and more attention from the medical community as a whole. This has boosted the effectiveness of the drugs' therapeutic benefits, reduced their adverse effects, and increase treatment participation.⁷⁹ The medical industry uses AuNPs made from a variety of seaweeds for a variety of purposes, including as antifungal agents against *Fusarium dimerism* but rather Human

insulin's, antibacterial agents against Gram +ve and Gram -ve bacterial pathogens, as well as antitumor against the liver and lungs in vitro cells such as through stimulation of cell damage. The small size of NPs affects the permeability or respiration of cell membranes by attaching to its surface, entering the cell, and further damaging Genetic. Vancomycin was used as a positive control, and Au-NPs made from Spiraling platen is displayed powerful antibacterial properties on Gram +ve microorganisms (Bacillus and Staphylococcus aureus). Through the dense peptidoglycan layer, protein-functionalized Au-NPs were able to harm the cell.⁸⁰

Antifouling agents

Aeromonas hydrophila were shown to be the most effective in suppressing microbial activity. The best method to manage issues brought on by bacteria in marine environments is to target new receptors implicated in biofilm formation. A comparison study of *Turbinaria conies*-derived character called Ag-NPs and Au-NPs was conducted by *Salmonella sp.*, Streptomycin liquefactions, & in *E. coli*, while Au-NPs were essentially ineffectual. Additionally, *Artemia Salina* *Artemia Salina* were killed by globular (2-17 nm) Ag-NPs with an LC50 value of 88.914 L mL⁻¹, confirming its effectiveness as a powerful anti-micro fouling agent. According to several researches, "nano-functionalized materials" that are coated, impregnated, or embedded with NMS prevent bacterial adherence or biofilm formation on surfaces.

Bioremediation

It has been discovered that nanoparticles offer an excellent platform for cleaning up pollutants brought on by different industrial effluents.⁸¹ Brown microalgae (*Turbinaria conies* or *Sargasso tenerrimum*) aqueous extracts were used by as a reducing agent for the manufacture of Au-NPs. Organic dye molecules and aliphatic nitrogen molecules (4-nitrophenol and p-nitro aniline) were reduced effectively by biosynthesized Au-NPs (*Rhoda mine B* and *Sulforhodamine*). The catalytic potential of *T. conies* was higher than that of *S. tenerrimum*. It was demonstrated that *Ulva lactic*-mediated stable Ag-NP production can be used at modest dosages to actively diminish populations of fluoroquinolones *Plasmodium falciparum* by active methyl orange degradation photo catalytic activity under visible light irradiation..

Table 1: Application of Different Metallic Nanoparticles

Nanoparticle	General Applications	Reference
AgNPs	Biomedical: drug deliver, cell imaging, cancer therapy and diagnosis	82
	Health care: Nutraceutical, Uv protection, topical creams and ointments	
	Environmental: Activated carbon filters, water disinfection, and waste water treatments	
AuNPs	Biomedical: Diagnostics such as in plasmodia biosensors, analytical methods and visualization, and bioimaging	83
	Therapy such as in photodynamic therapy ,photo thermal therapy, drug and gene delivery	
FeNPs	Biomedical: cancer therapy, cell labeling, drug delivery sytems, and MRIcontrast agents	84
ZnNPs	Biomedical: Tissue repair, wound healing, antineoplastic(cancer therapy), anti bacterial, angiogenesis	85
CuNPs	Biomedical: Biosensing and biolabeling	86
Pd NP	Medical diagnostics, biosensors, and material sciences	87

CONCLUSION

This review article gives a thorough understanding of their synthesis and preparation techniques. Scientists have been able to synthesis metal NPs utilising top-down and bottom-up strategies, including physical, chemical, and biological techniques, thanks to their metallic properties. Numerous bacteria may produce nanoparticles, which has several benefits. For a better knowledge of nanoparticle synthesis, different metal nanoparticle creation from bacteria, fungus, algae, and yeast has been focused on.

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