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A Review on Synthesis of Silver Nanoparticles

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ABSTRACT

This paper aims to present a brief review of different biosynthesis routes of silver nanoparticles (NPs), their applications and influence of the method used on the size and morphology of these nanoparticles. A detailed and comprehensive study of available biological methods, also referred to as a bottom-up approach, as well as techniques reported, have been provided with an eye for details and comparison between the techniques involving fungi, bacteria, algae and plant extracts. Plant-derived bioreductants such as leaf, stem or root extracts of various plants are seen as suitable solutions to green synthesis of silver NPs, implementing an easy, non-toxic, clean and environmentally friendly approach. Furthermore, reports on the antimicrobial activities with the zone of inhibition for various pathogens have also been included.

KEYWORDS: Silver nanomaterials, Bacteria, Fungi, Plant extract, etc.

INTRODUCTION

Nanotechnology is a strong area of science, engineering, and technology. Concerning the design and manufacture of materials at the nanoscale, the products of nanotechnology are nanomaterials or nanoparticles (NPs) with dimensions less than 100 nm. the nanoparticles have substantial applications in industrial, medical, and biotechnological sectors.

Use of plants in synthesis of nanoparticles is quite novel leading to truly green chemistry which provide advancement over chemical and physical method as it is cost effective and environment friendly easily scaled up for large scale synthesis and in this method there is no need to use high pressure, energy, temperature and toxic chemicals. Now a day we are using bacteria , fungi for the synthesis of nanoparticles but use of leaf extract reduce the cost as well as we do not require any special culture preparation and isolation techniques.

Plant extracts synthesis of silver nanoparticles is gaining significance due to its simplicity and eco-friendliness, as these methods do not use toxic chemicals for the synthesis protocol. The presence of various natural products in plants such as proteins, carbohydrates, steroids, alkaloids containing different functionalities i.e., –COOH, $–NH_2$, $–CONH_2$, and –OH could have the ability to reduce and stabilize AgNPs giving considerable simplicity to the systems.

Silver has been used in many traditional medicines of Ayurveda and Roman times, therefore attracted attention as antimicrobial agent. Silver nanoparticles were proved to be more efficient in their antimicrobial activities against bacteria, fungi, viruses and other eukaryotic microorganisms.

In a world threatened by the rise of antimicrobial resistance, the use of silver nanoparticles in drug delivery systems may help solve this emerging problem. Therfore, their large-scale synthesis has the potential of being extremely useful, espically in healthcare. Biological methods can prove to be more suitable for large-scale synthesis, thereby providing a sustainable method to exploit their antimicrobial activity.

LITERATURE SURVEY

Abdulaziz Yahya Al-Ghamdi studied Antimicrobial and Catalytic Activities of Green Synthesized Silver Nanoparticles Using BayLaurel (*Laurus nobilis*) Leaves Extract. They reported, The essential oil of bay laurel contains many active materials such as terpineol and cineol[1]. It has shown antimicrobial and antifungal characteristics as well as hypoglycaemic and antiulcerogenic properties [2].

Mehrdad Forough, Khalil Farhadi reported Biological and green synthesis of silver nanoparticles. They studied A critical need in the field of nanotechnology is the development of reliable and eco-friendly processes for synthesis of metallic nanoparticles. Here, we have reported a simple biological and low-cost approach for preparation of stable silver nanoparticles by reduction of silver nitrate solution with a bioreduction method using manna of hedysarum aqueous extract as the reducing agent. Soap-root extract was employed as a stabilizing agent. Biologically synthesized silver nanoparticles could be of immense use in medical textiles for their efficient antibacterial and antimicrobial properties[3]. The reduction of silver nitrate to silver nanoparticles with high stability and without any impurities.

Ratul Kumar Das, Vinayak Laxman Pachapur, Linson Lonappan,Mitra Naghdi, Rama Pulicharla, Sampa Maiti, Maximiliano Cledon,Larios Martinez Araceli Dalila, Saurabh Jyoti Sarma, Satinder Kaur Brar, worked on Biological synthesis of metallic nanoparticles: plants, animals and microbial aspects. They reported, The green synthesis (GS) of different metallic nanoparticles (MNPs) has re-evaluated plants, animals and microorganisms for their natural potential to reduce metallic ions into neutral atoms at no expense of toxic and hazardous chemicals. GS with animal-derived biomaterials, such as chitin, silk (sericin, fibroin and spider silk) or cell extract of invertebrates have also been reported.

Antariksh Saxena, R.M.Tripathi, R.P.Singh studied Biological synthesis of Silver Nanoparticles by using Onion (*Allium cepa*) extract and their antibacterial activity . We have reported a fast, convenient and extracellular method for the synthesis of silver nanoparticles by reducing silver nitrate with the help of onion (*Allium cepa)* extract. Here we report synthesis of silver nanoparticles, reducing Ag+ ions present in the aqueous solution of auric acid by the extract of onion extract. Through elaborate screening process involving number of plants we observed that onion (*Allium cepa)* were potential candidate for synthesis of silver nanoparticles. The formation of nanoparticles was done by using UV- Vis Spectrophotometer and Dynamic Light Scattering (DLS). The morphology of silver nanoparticles was confirmed by Transmission Electron microscopy (TEM). We also study the antibacterial property of silver nanoparticles toward E.coli and Salmonella typhimurium. Although, several previous reporter have been study the antibacterial activity of chemically synthesised silver nanoparticles[4] but here we study the biologically (using onion extract) synthesise silver nanoparticles.

Amira L. Hanna, Hayam M.Hamouda, Hanan A.Goda, Mahmoud W.Sadik,, Farahat S. Moghanm, Adel M. Ghoneim , Muneefah A. Alenezi, Sultan F. Alnomasy, Pravej Alam, and Tarek R. Elsayed reported Biosynthesis and Characterization of Silver Nanoparticles Produced by *Phormidium ambiguum* and *Desertifilum tharense* Cyanobacteria. They reported The cyanobacterial synthesis of NPs is accomplished extracellularly or intracellularly. Extracellular biosynthesis involves the secretion of extracellular substances to mediate through electrostatic interactions or the production of extracellular reductase enzymes. Alternatively, the intracellular production of NPs associates with the activity of reductase enzymes and substance exchange processes [5,6]. The best results were observed using culture supernatants, especially under light conditions, because of microbial products that facilitate this reaction extracellularly. Therefore, further characterization tests were needed to assess the antibacterial and antioxidant activities of Ag-NPs synthesized extracellularly under light conditions. These cyanobacteria can produce smaller spherical particles with face-centered cubic structures. Presence of amides and

hydroxyl groups indicates that proteins and polysaccharides could be considered important factors in the biosynthesis of Ag-NPs. Generally, the characterization assay showed that novel *Desertifilum tharense* cyanobacteria have superior power in the green synthesis of Cyano-AgNPs. The current findings indicate that the biosynthesized AgNPs may be potent antibacterial agents against different pathogenic bacteria and could be used as alternatives to antibiotics.

Cheah Liang Keat, Azila Aziz, Ahmad M Eid, and Nagib A. Elmarzugi, reported Biosynthesis of nanoparticles and silver nanoparticles. The findings of this review are important to provide an alternative for the green synthesis of silver nanoparticles. It showed more cost-effective and environmental friendly application as well as easier for large production, with relation to the properties of silver nanoparticles as antimicrobial, can be served well as an alternative antiseptic agent in various fields.

Kumari Jyoti, Mamta Baunthiyal, Ajeet Singh studied Characterization of silver nanoparticles synthesized using *Utrica dioica* Linn. Leaves and their syngergistic effects with anticiotics. *Utrica dioica* Linn is a herbaceous perennial flowering plant of the *Urticaceae* family. This plant has been reported to possess antibacterial, antifungal, antiviral, antioxdative activity[7]. The phytosynthesis of AgNPs using U.dioica leaves extract us cost effective, simple and eco-friendly method that excludes the hazards arising out of the use of harmful reducing/capping agents. Moreover, this process could be easily scaled up for the industrial applications to increase the yield of the nanoparticles significantly, which undoubtedly would establish its commercial viability in medicine.

Singaravelu Vivekanandhan, Laura Christensen, Manjusri Misra, Amar Kumar Mohanty studied Green Process for Impregnation of Silver Nanoparticles into Microcrystalline Cellulose and Their Antimicrobial Bionanocomposite Films. A novel greener method to impregnate silver nanoparticles (AgNPs) into microcrystalline cellulose (MCC) by curry leaf (*Murraya koenigii*) extract is presented. The active reduction of silver ions by curry leaf extract was explored for the in situ impregnation AgNPs into MCC. Transmission electron microscopy (TEM) analysis of MCC coated with AgNPs showed the formation of silver particle sizes in the range of 10 - 25 nm and have a spherical shape. Further the, EDS analysis of MCC/Ag nanocomposite confirms the formation of Ag structure on microcrystalline cellulose. Solvent casting of poly(lactic-acid) was used to produce composite films containing silver impregnated MCC aiming for antimicrobial applications. we have reported the "green" method of synthesizing AgNPs using curry leaf (*Murraya koenigii*) extract[8] . The present research is aimed to impregnate AgNPs into microcrystalline cellulose using *Murraya koenigii* extract as the reducing agent at ambient conditions and extending their application into the fabrication of polylactic acid (PLA) based antimicrobial Bionanocomposite films.

Shweta Rajawat, Mohammad Shums Qureshi studied Comparative Study on Bactericidal Effect of Silver Nanoparticles, Synthesized Using Green Technology, in Combination with Antibiotics on *Salmonella typhi*. In this work bactericidal study of silver nanoparticles was taken up in combination with two standard antibiotics, ampicillin and gentamycin, for *Salmonella typhi*. The antibacterial activities of antibiotics were increased in the presence of AgNPs against test strains. The higher enhancing effect was observed for ampicillin in comparison to gentamicin against test strains.

K. Satyavani, T.Ramanathan, S.Gurudeeban reported Green synthesis of silver nanoparticles by using stem derived Callus extract of Bitter Apple (*Citrullus colocynthis*). In the present investigation, synthesis of silver nanoparticles by using stem derived callus extracts of *Citrullus colocynthis* (L.) Schrader. The extract incubated with AgNO3 showed gradual change in the colour of the extract from greenish to reddish brown it indicate the silver nanopaticles synthesis. The shape of the SNP synthesized by stem derived callus extract was spherical and was found to be in the range of 75 nm by AFM. FTIR absorption spectra conclude that the compounds attached with silver nanoparticles could be polyphenols with aromatic ring and bound amide region. The novel silver nanoparticles exhibited a tremendous antibacterial activity; it showed the maximum activity against bioflim bacteria such as *E.coli* (10.1 mm), *V. paraheamolyticus* (10.1 mm), *P. aeruginosa* (8 mm), *Proteus vulgaris* (9

mm) and *L. monocytogens* (8 mm) and also observed that it showed no activity against *Proteus mirabilis, Salmonella enteritidis,* and *Staphylococcus aureus.*

Sweta Mishra, Pratyush Kumar Das studied Green synthesis of silver nanoparticles: properties and action against bacterial biofilms.They reported AgNPs are also generated from silverware, even when we drink water from silverware or use silver cutlery we consume AgNPs and people are using silver cutlery for over millennia [9]. Colloidal silver, suspensions of silver nanoparticles in liquid were used even before antibiotics. The antimicrobial properties of silver are considered an effective way against the eradication of bacterial biofilms, a group or consortium of microorganisms that are attached with each other and even attached to the surface they are in through the production of a slimy layer made up of exopolysaccharides. These biofilms are responsible for the antibiotic resistance of various bacterial species. The application of AgNPs against bacterial biofilms is effective due to multiple mechanisms that it uses like DNA damage, protein denaturation, membrane damage by the accumulation of AgNPs, generation of ROS, and many more. That is the reason why in this review, the basic focus is on the different methods used for green synthesis of AgNPs, evaluation of their properties that make the particles have varied application in different fields, and most importantly the application of AgNPs as antimicrobial agents against bacterial biofilms. The AgNPs show ability to combat bacterial biofilms and this can be useful for upsurge for new antimicrobial agents due to growing cases of antimicrobial resistance. Therefore, this review addresses and emphasizes the plant or microbial-based green synthesis with properties of AgNP that can be useful in multidisciplinary applications mostly the biological field. Also, the mechanisms against bacterial biofilms have been put forth in hope of intriguing more research enthusiasm towards optimizing and upgrading these AgNPs as antibacterial agents.

Mohammad A. Khalilzadeh, Mina Borzoo studied Green synthesis of silver nanoparticles using onion extract and their application for the preparation of a modified electrode for determination of Ascorbic acid. They studied a green synthesis of AgNPs by reduction of silver ions using aqueous and alcoholic onion extracts for facile and fast phytosynthesis of AgNPs. The ability of AgNPs to reduce charge transfer resistance and the effect of these extracts on ascorbic acid signal using electrochemical impedance spectroscopy (EIS) and voltametric methods is also investigated. To the best of our knowledge, only one report describing the synthesis of AgNPs using water extracts of onion can be found in the literature[10] and no further reports pertaining to the use of methanolic onion extract for green synthesis of AgNPs and its effect on ascorbic acid signal by square wave voltammetry (SWV) have been published. The high pheolic content of the water extract of onions having strong properties helps to reduced the Ag cations to AgNPs.

Priya Banjerjee, Mantosh Satapathy, Aniruddha Mukhopahayay and Papita Das studied Leaf extract mediated green synthesis of silver nanoparticles from widely available Indian plants: synthesis, chatacterization, antimicrobial property and toxicity analysis. This study investigates an efficient and sustainable route of AgNP preparation from 1mM aqueous $AgNO_3$ using leaf extract of three plants, *Musa balbisina* (banana), *Azardirachta indica* (neem) and *Ocimum tenuiflorum* (black tulsi), well aborned for their wide availability and medicinal property. In this research paper silver nanoparticles were successfully obtained from bioreduction of silver nitrate solutions using banana, neem and tulsi leaf extracts. Owing to varying properties of these three plants species, AgNPs obtained from them also varied in size, the smallest being yield using banana leaf extracts.

Hina Ashraf1, Tehmina Anjum, Saira Riaz and Shahzad Naseem studied Microwave-Assisted Green Synthesis and Characterization of Silver Nanoparticles Using *Melia azedarach* for the Management of *Fusarium* Wilt in Tomato. The current investigation involved the green synthesis of silver nanoparticles (AgNPs) from the aqueous leaf extract of *Melia azedarach* by following a microwave-assisted method to control *Fusarium oxysporum*, the causal agent of tomato wilt. nanoparticle (NP) synthesis which has many advantages including its biocompatibility, scalability, and applicability by utilizing water which acts as a reduction medium [11]. It has been recommended that vitamins, proteins, organic acids, amino acids, and secondary metabolites act like capping and stabilizing agents that reduce metal salts of synthesized NPs by playing a key role [12].

Mohammad Ali, Bosung Kim, Kevin D. Belfield, David Norman, Mary Brennan, Gul Shad Ali studied Green synthesis and characterization of silver nanoparticles using *Artemisia absinthium* aqueous extract — A comprehensive study In this study we showed that *A. absinthium* mediated AgNP biosynthesis is strongly dependent on the relative concentrations of plant extract and AgNO3. The higher concentrations of plant extract or AgNO3 resulted in bigger sized nanoparticles.

Aparajita Verma, Mohan Singh Mehata reported Controllable synthesis of silver nanoparticles using Neem leaves and their antimicrobial activity. The rich biodiversity and easy availability of plant entities have been highly explored for the nanomaterials synthesis [13]. The phytochemicals present in Neem are namely terpenoids and flavanones, which act as reducing as well as capping agent and helping in stabilizing the nanoparticles. When silver salt is treated with Neem leaf extract, the silver salt is reduced to AgNPs. The synthesized nanoparticles, which are capped with neem extract also exhibit enhanced antibacterial activity.

B. Ajitha, Y. Ashok Kumar Reddy***, P. Sreedhara Reddy Green synthesis and characterization of silver nanoparticles using Lantana camara leaf extract Studied*** Green synthesized AgNPs have tremendous applications such as spectrally selective coatings for solar energy absorption and intercalation material for solar energy batteries, as optical receptors, catalysts in chemical reactions, biolabelling, and as antimicrobial agent.

The reduction of Ag+ to Ag0 nanoparticles using L. camara leaf extract was ascribed due to the presence of phenolics, flavonoids, terpenoids, alkaloids, lipids, proteins and carbohydrates in the leaf extract[14,15]. Hence, leaf extract plays a dual role as both reducing and capping agents simultaneously without any involvement of chemicals.

Palaniselvam Kuppusamy, Mashitah M. Yusoff, Gaanty Pragas Maniam, Natanamurugaraj Govindan reported Biosynthesis of metallic nanoparticles using plant derivatives and their new avenues in pharmacological applications. The plant mediated nanoparticles are potential remedy for various diseases such as malaria, cancer, HIV, hepatitis and other acute diseases. These biological synthesized nanomaterials have potential applications in different areas such as treatment, diagnosis, development surgical nanodevices and commercial product manufacturing [16]. Based on that, the review focused on biosynthesized metallic nanoparticles from plant derivatives and its application in medical and commercial sectors including waste water treatment, cosmetics and food industry.

Shakeel Ahmed, Saifullah, Mudasir Ahmad, Babu Lal Swami, Saiqa Ikram reported Green synthesis of silver nanoparticles using *Azadirachta indica* aqueous leaf extract. Simple one-pot green synthesis of stable silver nanoparticles using *A. indica* leaf extract at room temperature was reported in this study. Synthesis was found to be efficient in terms of reaction time as well as stability of the synthesized nanoparticles which exclude external stabilizers/reducing agents. It proves to be an eco-friendly, rapid green approach for the synthesis providing a cost effective and an efficient way for the synthesis of silver nanoparticles.

Shakeel Ahmed, Mudasir Ahmad, Babu Lal Swami, Saiqa Ikram. A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertis. For biomedical applications; being added to wound dressings, topical creams, antiseptic sprays and fabrics, silver functions' as an antiseptic and displays a broad biocidal effect against microorganisms through the disruption of their unicellular membrane thus disturbing their enzymatic activities.

The present review explores the huge plant diversity to be utilized towards rapid and single step protocol preparatory method with green principles over the conventional ones and describes the antimicrobial activities of silver nanoparticles. It can be concluded that the benefit of synthesis of silver nanoparticles using plant extracts is that it is an economical, energy efficient, cost effective; provide healthier work places and communities, protecting human health and environment leading to lesser waste and safer products.

Hasnain Muhammad Ashraf Sabri , Asim Umer, Gul Hameed Awan , Muhammad Faheem Hassan and Azhar -Selection of Suitable Biological Method for the Synthesis of Silver Nanoparticles. They reported a

brief overview of different biosynthesis routes of silver nanoparticles (NPs), their applications and influence of the method used on the size and morphology of these nanoparticles. A detailed and comprehensive study of available biological methods, also referred to as a bottom-up approach, as well as techniques reported, have been provided with an eye for details and comparison between the techniques involving fungi, bacteria, algae and plant extracts.

Manoranjan Behera , Ardhendu Sekhar Rout , Arpita Tripathy-Green Synthesis of Silver Nanoparticles Using Raw Fruit Extract of *Mimusops elengi* and their Antimicrobial Study. Green synthesis is such an approach of synthesizing NPs using microorganisms and plants, which is free of additional impurities. We used *Mimusops elengi* Linn. raw fruit extract in water to reduce the silver nitrate salt to produce silver NPs.

Aqueous flower extract of *Mimusops elengi*, Linn was used in the synthesis of Ag NPs, and NPs were characterized using UV-Visible & FTIR spectrophotometer and SEM. They have reported potential antibacterial activity against both gram-positive like Staphylococcus *aureus* and a gramnegative *E. coli* bacteria [17]. Kiran Kumar et al.[18] have synthesized Ag NPs using the *Mimusops elengi* seed extract and characterized the sample using UV-Visible spectroscopy, FTIR spectroscopy, and TEM. The synthesized Ag NPs were found to be sensitive against both Staphylococcus *aureus (S. aureus) and Escherichia coli (E. coli)*. These NPs also acted as an antioxidant agent against ascorbic acid.

synthesis routes mentioned above, green synthesis is preferred the most as in the rest of other methods, various chemicals are used that are toxic in nature. In order to do the green synthesis, more eco-friendly plant-mediated nanoparticle synthesis is the best choice, as this avoids the use of toxic, carcinogenic, harsh, and expensive chemicals[19].

Protima Rauwel, Siim Küünal, Stanislav Ferdov, and Erwan Rauwe-A Review on the Green Synthesis of Silver Nanoparticles and Their Morphologies Studied via TEM-They reported

Green chemistry should aim at thwarting waste, minimizing energy use, employing renewable materials, and applying methods that minimize risk. The three main concepts for the preparation of nanoparticle in a green synthesis approach are the choice of the solvent medium (preferably water), an environmentally friendly reducing agent, and a nontoxic material for the stabilization of the nanoparticles[20]. To be energy efficient, the synthesis processes should be carried out close to ambient temperature and pressure and under neutral pH. The biological systems then appear as the most suitable factory for reaching such natural chemistry conditions. It is well known that many microorganisms can provide inorganic materials either intra- or extracellularly [21] and it was found that some of these microorganisms can be used as ecofriendly nanofactories for the production of nanomaterials, more particularly for the production of silver metal nanoparticles (Ag NPs).

Fungi present a suitable option for large-scale green nanoproduction. They are easy to handle during downstream processing and they secrete large amounts of enzymes needed in the reduction. They also present filamentous tolerance towards metals, high binding capacity, and intracellular uptake. Nevertheless, the genetic manipulation to overexpress specific enzymes in order to intensify synthesis is much more difficult among eukaryotes.

Abdur Rahim, Muhammad Balal Arain they included by Biologically Synthesized Silver Nanoparticles-based Colorimetric Sensor for the Selective Detection of Zn2+.They reported A simple, selective and cost effective colorimetric sensor has been investigated for the detection of Zn2+ using biologically synthesized silver nanoparticles (AgNPs). The AgNPs were prepared from the leaf extract of *Amomum subulatum* via two different procedures i.e., at room temperature and by a heat treatment procedure. The AgNPs prepared through the heat treatment procedure exhibited efficient results.

Ag nanoparticles, sensitive, low cost and rapid colorimetric sensors have been developed for the detection of various organic molecules and heavy metal ions in biological and environmental samples.[22,23].

Abdulaziz Yahya Al-Ghamdi studied Antibacterial Activity of Green Synthesis Silver Nanoparticles Using Some Wild Edible Plants Commonly Used in Al Baha, Saudi Arabia. They reported aqueous extract of *Cissus rotundifolia* (Wild edible plants) was used as a reducing and capping agent in the formation of silver nanoparticles (AgNPs). These plants are rich in minerals, vitamins, dietary fiber, fatty acids and amino acids[24].

The current investigation was carried out to screen the antibacterial activity of green synthesis silver nanoparticles using wild edible plants extract against some pathogenic bacterial strains.

The presence of anti-nutritional principles in some species of wild plants, such as phytic acid, tannins, saponins, alkaloids and oxalates, can limit their exploitation[25]. The mechanism of AgNPs as an antimicrobial is not understood, but many studies suggest that it occurs through the interaction of silver nanoparticles with the DNA of microorganisms, forming free radicals and destructuring the cell walls[26]

The current investigation was carried out to screen the antibacterial activity of green synthesis silver nanoparticles using wild edible plants extract against some pathogenic bacterial strains.

G.Geoprincy, B.N.Vidhya Sree, U.Poonguzhali, N.Nagendra Gandhi, S.Renganthan A review on green synthesis of silver nanoparticles. They reported the synthesis of metal and semiconductor nanoparticles is a vast area of research due to its potential applications which was implemented in the development of novel technologies[27].

The characterization analysis proved that the particle so produced in nanodimensions would be equally effective as that of antibiotics and other drugs in pharmaceutical applications. The use of silver nanoparticles in drug delivery systems might be the future thrust in the field of medicine. With respect to the clinical applications of nanoparticle, microorganisms including diatoms, fungi, bacteria and yeast producing inorganic materials through biological synthesis either intra or extracellularly made nanoparticles more biocompatible [28].

Habeeb Khadri1 , Mohammad Alzohairy1 , Avilala Janardhan2 , Arthala Praveen Kumar2 , Golla Narasim studied Green Synthesis of Silver Nanoparticles with High Fungicidal Activity from Olive Seed Extract. They reported Silver nanoparticles in the form of silver based chemicals trace back their origin to time immemorial since the dilute forms of silver nitrate were used in place of antibiotics before they dominated the field of medicine.

The natural products such as monosaccharide or plant extracts have been used as reducing agents during these studies. Microbiological methods are much slower than plant extracts and other chemical reducing agents for production of nanoparticles as observed from many studies. In general, all the biological systems are rich in reductase enzymes and olive plant is no exception, and they obviously carry the ability of reducing inorganic salts to their respective elemental forms and this mechanism has been exploited earlier and the present attempt is to use olive seeds for reducing silver nitrate salts to metallic silver and olives that have an advantage because of their inherent antimicrobial abilities.

The olive plant has excellent antifungal properties. Olive cakes have shown antifungal properties against several fungi like Fusarium, Rhizopus, Stemphylium, Rhizoctonia, Alternaria etc. In our current study, the silver nanoparticles have been synthesized using screened extracts of the olive plant seeds and report that silver nanoparticles can be applied effectively in the control of microorganisms and the prevention of deleterious infections. Our results support the hypothesis that Ag nanoparticles can be prepared in a simple and cost-effective manner and are suitable for formulation of new types of fungicidal agents.

M. Prathap, A. Alagesan, B.D. Ranjitha Kumari concluded by Anti-bacterial activities of silver nanoparticles synthesized from plant leaf extract of *Abutilon indicum* (L.) Sweet .

The nano silver was successfully synthesized from leaf extract using A. indicum (L.) Sweet. Nitrate reductase enzyme or other extra cellular proteins released from leaf extract involve in reduction of nitrate and formation of silver ions occurs. These proteins or enzymes act as template for the silver nucleation sites for the formation of silver nanocrystals and also act as capping agents (peptides or proteins) which control the size and shape of silver nanoparticles. Sweet leaf protein molecules plays a vital role in reducing and capping of silver nanoparticles which act as anti-bacterial agent to control pathogenic microorganisms of *Klebsiella pneumonia, Salmonella typhi, Bacillus subtilis,* and *Proteus vulgaris.*

Silver nanoparticles have found tremendous applications in the field of high sensitivity bio-molecular detection, diagnostics, catalysis and micro-electronics. A number of approaches are available for the synthesis of silver nanoparticles for example, reduction in solutions, chemical and photochemical reactions in reverse micelles, thermal decomposition of silver compounds, radiation assisted, electro chemical, sono-chemical, microwave-assisted process, and recently via green chemistry route. The understanding of capping of biological moiety is derived from Fourier transform infrared spectroscopy and the thermo gravimetric analysis[29].

Dr. Gudikandula Krishnaa, Dr. Pranitha Vadapallyb, Prof. M. A. Singara Charyaa-Biogenic synthesis of silver nanoparticles from white rot fungi: Their characterization and antibacterial studies. They reported, the antimicrobial potential of synthesized Ag nanoparticles was tested against bacterial pathogens by agra well diffusion assay. The AgNPs was showing strong antimicrobial potential against the tested bacteria. The present study is eco-friendly need cheaper cultivation requirements, higher rates of growth on laboratory scales. Current findings not only confirm the nanoparticle formation, but also implicate the effective and efficient antimicrobial property of silver nanoparticles.

Biosynthesized silver nanoparticles produced by the fungi *Trametes ljubarskyi* and *Ganoderma enigmaticum* were tested for antimicrobial activity as method suggested by [30] using various Gram-positive and Gram-negative bacteria by the agar well-diffusion method. Development of antibiotics or other chemotherapeutics revolutionized human health, providing a simple cure for once dreaded diseases. Inspite, widespread production, use, and misuse of antibiotics have contributed to the next-generation concern for global public health: the emergence of multiple drug-resistant infectious organisms and cancer cells[31].

Md. Mahidul Islam Masum, Mst. Mahfuja Siddiqa , Khattak Arif Ali, Yang Zhang, Yasmine Abdallah, Ezzeldin Ibrahim, Wen Qiu, Chenqi Yan and Bin Li studied Biogenic Synthesis of Silver Nanoparticles Using *Phyllanthus emblica* Fruit Extract and Its Inhibitory Action Against the Pathogen *Acidovorax oryzae* Strain RS-2 of Rice Bacterial Brown Stripe.This study suggested that AgNPs can be an attractive and eco-friendly candidate to control rice bacterial disease. *Phyllanthus emblica* L. (Family: Phyllanthaceae) commonly known as emblica/amla exhibits a striking assortment of shapes of development such as herbs and bushes, pachycaulous succulents, climbers, and drifting aquatics. The fruits of *Phyllanthus* spp. are widely used in preparation of traditional medicines in Southeast Asia due to unique properties such as rich antioxidant activity, antiaging, antipuretic, and anti-inflammatory (Dang et al., 2011; Pientaweeratch et al., 2016; Manikandan et al., 2017). many pharmacognosy and phytochemistry investigations have been successfully conducted in this plant, its opportunity as biocompatible materials for the production of AgNPs is still to be fully scanned. In addition, there is no report on the inhibitory effect of AgNPs mediated by plants against rice pathogenic bacteria *Acidovorax oryzae* (Ao).

Sahu ***Ajay Kumar, Harichandan S.S Priyadarshini, Acharya Prangya Paramita, Samal Pinki, Gautam Sakshi, Barsha Rani Kar and B Kumar Kiran reported*** Green synthesis and biochemical characterization of silver nanoparticles by using *Euphorbia umbellata* leaf extract and analysis of antimicrobial activity against plant pathogens.They reported Silver nanoparticles is embedded with antibacterial properties because of its unique properties is considered in medical science, the main aim of work is green synthesis of silver nanoparticles using *Euphorbia Umbellate* leaf extract and its antibacterial activity, after the collection of sample, identification and extraction of *Euphorbia Umbellate* was performed the production of silver nanoparticles.

Although toxic and very caustic to the skin and mucous membranes, the latex has sometimes been used internally, particularly to deal with internal parasite, several drops of latex from warmed leaves are taken to latex to expel intestinal parasites and sometimes tapeworm, the leaf sap is also used to treat cardiac problems and excessive menstruation [33]. A few drops of the latex are applied topically to warts, the latex is also applied to source as a treatment for syphilis, and the latex is applied to order abscesses in order to mature them [34]. Use of plant extracts for nanoparticles synthesis is favorable over the other biological material as it removes the long process of maintenance of cell culture.

Ahmad, Seema Sharma studied Green Synthesis of Silver Nanoparticles Using Extracts of *Ananas comosus*. In the present study, synthesis of silver nanoparticles (AgNPs) or (Green-Silver) has been demonstrated using extracts of *Ananas comosus* reducing aqueous silver nitrate. The different types of antioxidants presented in the pineapple juice synergistically reduce the Ag metal ions, as each antioxidant is unique in terms of its

structure and antioxidant function. This work proved the capability of using biomaterial towards the synthesis of silver nanoparticle, by adopting the principles of green chemistry.

Ananas comosus L. belongs to Bromeliaceae family. Pineapple has several beneficial properties including antioxidant activity. It contains enzymes which are a mixture of protease and which are known and sold as a nutritional supplement to "promote digestive health" and as an anti-inflammatory medication[35]. It has been applied in the anticancer activity and in the immunization of influenza virus[36].

Pineapple contains a number of essential nutrients, including vitamin C, manganese, and fibre. It also contains beneficial plant phytochemicals (Ferulic acid and chlorogenic acid) which have antioxidant and anti-cancer activities.

High radical scavenging capacity presented in the pine apple extract is the chlorogenic acid. Chlorogenic acids are more efficient scavengers of free radicals than benzoic acid derivatives[37,38]. Thus the different types of antioxidants presented in the pineapple juice synergistically reduce the Ag metal ions as each antioxidant is unique in terms of its structure and antioxidant function of trapping the different free radicals.

Sista Kameswara Srikar, Deen Dayal Giri, Dan Bahadur Pal, Pradeep Kumar Mishra, Siddh Nath Upadhyay studied Light Induced Green Synthesis of Silver Nanoparticles Using Aqueous Extract of *Prunus amygdalus.* In the present work, aqueous extract of *Prunus amygdalus* was used to produce AgNPs, whose synthesis is mediated by the photons present in the sunlight. Aqueous extract of *Prunus amygdalus* is an effective biological agent for synthesizing stable (20 days) and spherical AgNPs (~20 nm). Alcoholic groups presented in the extract promote the AgNPs synthesis and amide groups promote the stabilizing action. Violet portion of visible light supports the synthesis of AgNPs. Sunlight, photo catalyzed the reducing action of biological agent.

Sujata Mandal, Sreekar B. Marpu, Roxana Hughes, Mohammad A. Omary, Sheldon Q. Shi Green Synthesis of Silver Nanoparticles Using *Cannabis sativa* Extracts and Their Anti-Bacterial Activity. They reported the green synthesis of silver nanoparticles (AgNPs) using *Cannabis sativa* (hemp plant) as a stabilizing media was developed and antibacterial activity was tested. The antibacterial activity of these nanoparticles was studied on Gram-positive Staphylococcus aureus, and Gram-negative Escherichia coli. The biosynthesis of silver nanoparticles using hemp extract could be a simple, inexpensive, and biocompatible method.

Hemp (*Cannabis sativa*) mainly contains cellulose, hemicellulose, and lignin, and has been widely cultivated in many tropical countries for its fiber content[39]. It is also noted as a good source of pharmaceutical ingredient[40], as it contains various bioactive substances like cannabinoids, terpenes, ketones, fatty acids, and phenolic compounds demonstrated for their antibacterial, antifungal, anti-inflammatory, and anticancer properties[41,42]. This emerging innovation could become a substitute for chemically synthesized AgNPs and significantly improve the application of hemp hurd extract towards water filtration applications.

Laura Castro, María Luisa Blázquez, Jesus Angel Muñoz, Felisa González, Antonio Ballester studied Biological synthesis of metallic nanoparticles using algae.They reported Algae are eukaryotic aquatic oxygenic photoautotrophs, and some of them are able to accumulate various heavy metals. *Spirulina platensis* is an edible blue–green alga and the dried alga was used for the extracellular synthesis of gold, silver and Au/Ag bimetallic nanoparticles[43]. silver nanoparticles was also attained with the green alga *S. insignis* under the optimal conditions of synthesis including the possibility of metal recovery by sorption on the biomass surface.

Hamouda, Mervat H. Hussein, RashaA.Abo-elmagd & Salwa S. Bawazir Synthesis and biological characterization of silver nanoparticles derived from the cyanobacterium *Oscillatoria limnetica,* This study indicated that the green synthesized silver nanoparticles via simple biological protocol using *Oscillatoria limnetica* aqueous extract that supplied both reducing and stabilizing agent for the biosynthesis of nanoparticles where the extracellular biosynthesis of O-AgNPs facilitates the process for downstream processing. Te biosynthesized O-AgNPs have a synergetic bactericidal potential (accompanied with antibiotics) advantages as biocontrol mediators for some human pathogenic bacteria (E. coli and B. cereus) according to its stability and minor size. In addition O-AgNPs exhibited low haemolytic activity may be useful in administration of some

medical devices as well as having cytotoxic action on some human cell lines (breast (MCF-7) cell line and human colon cancer (HCT-116). O-AgNPs characterization may be introduced a promising applications in medicine, cosmetic and pharmaceutical industries.

Cynthia Mason, Singaravelu Vivekanandhan, Manjusri Misra, Amar Kumar Mohanty studied Switchgrass (*Panicum virgatum*) Extract Mediated Green Synthesis of Silver Nanoparticles. They reported Silver nanoparticles were successfully synthesized using switchgrass extract used at room temperature. Present research has prompted for further exploration in the use of plant extracts for the synthesis of silver nanoparticles from switchgrass extract. Switchgrass is a warmseason perennial plant that requires minimal agriculture inputs (including pesticides, energy, and fertilizer), with the ability to survive on marginal lands, providing economic and environmental advantages. Switchgrass has been widely used as fuel for generating energy and is currently used as feedstock for bio-ethanol production. Despite these developments in its many uses, there are currently no reports that show the bio-reduction mechanism of switchgrass extract for the synthesis of silver nanoparticles. This report outlines the use of switchgrass extract as the reducing agent in the reaction that converts silver ions into silver nanoparticles.

Sonali Pradhan studied by Comparative analysis of Silver Nanoparticles prepared from Different Plant extracts (*Hibiscus rosa sinensis, Moringa oleifera, Acorus calamus, Cucurbita maxima, Azadirachta indica*) through green synthesis method. In this present study five plants *Hibiscus rosa sinensis, Cucurbita maxima, Moringa oleifera, Azadirachta indica and Acorus calamus* were taken to investigate their potential for synthesizing silver nanoparticle. All the five plants synthesized silver nanoparticle show good antimicrobial activity against clinically important pathogens Staphylococcus aureus, Klebsiella pneumoniae, Vibrio cholera and Escherichia coli. By comparing the different characteristic data we could conclude that AgNPs synthesised from *H. sinensis* and *C. maxima* were less stable then the other three plant extracts which could be due to the absence of capping and stabilizing materials as petals mainly contains pigments for attracting different insects for pollination.

Nabeel Ahmad , Kavya Shree , Monisha Srivastava , Rajiv Dutta Novel rapid biological approach for synthesis of silver nanoparticles and its characterization.The main aim of their work was the development and characterization of silver nanoparticles through biotransformation by *Catharanthus roseus*. From the qualitative analysis it is clear that the *C. roseus* is a medium for the reduction of Ag+ that generates silver nanoparticles. These nanoparticles can be used as a drug for various diseases like antimicrobial, antifungal and cancer treatment. Due to the smaller size these nanoparticles have great tendency to penetrate the tumors especially for cancer cell.

Priyabrata Mukherjee, Absar Ahmad, Deendayal Mandal, Satyajyoti Senapati, Sudhakar R. Sainkar, Mohammad I. Khan, Renu Parishcha, P. V. Ajaykumar, Mansoor Alam, Rajiv Kumar and Murali Sastry, reported as Fungus-Mediated Synthesis of Silver Nanoparticles and Their Immobilization in the Mycelial Matrix: A Novel Biological Approach to Nanoparticle Synthesis. They reported a A novel biological method for the synthesis of silver nanoparticles using the fungus *Verticillium* is reported. Exposure of the fungal biomass to aqueous Ag+ ions resulted in the intracellular reduction of the metal ions and formation of silver nanoparticles of dimensions 25 ± 12 nm. The metal ions were not toxic to the fungal cells and the cells continued to multiply after biosynthesis of the silver nanoparticles.

Developing on the strategy to enlarge the scope of bioorganisms in the synthesis of nanomaterials, we demonstrate herein that the fungus *Verticillium* (AAT-TS-4), when exposed to aqueous $AgNO_3$ solution, causes the reduction of the metal ions and formation of silver nanoparticles of ca. 25 nm diameter. The silver nanoparticles are formed below the surface of the fungal cells with negligible reduction of the metal ions observed in solution. It is to be noted that, in contrast to the earlier studies on the use of yeast cells in the synthesis of metal sulphides[44,45], metallic silver nanoparticles are obtained with the fungus *Verticillium*, thus pointing to a radically different mechanism for the reduction of the Ag+ ions present in solution

In conclusion, the bioreduction of aqueous Ag+ ions by the fungus *Verticillium* has been demonstrated. The reduction of the metal ions occurs on the surface of the mycelia leading to the formation of silver nanoparticles of fairly well-defined dimensions and tolerable monodispersity.

Deepika Hebbalalu,Jacob Lalley, Mallikarjuna N. Nadagouda and Rajender S. Varma study by Greener Techniques for the Synthesis of Silver Nanoparticles Using Plant Extracts, Enzymes, Bacteria, Biodegradable Polymers, and Microwaves. They reported Green tea (Camellia sinensis) extracts can act as reducing and

stabilizing agents in AgNP production. Colloidal systems of these particles exhibited highly efficient, single-photon induced luminescence, which could be manipulated by changing the silver ion concentration[46]. Furthermore, Nadagouda and Varma3 investigated the use of not only tea extracts, but also coffee extracts. Generally, tea extracts produced larger particles than coffee extracts, according to this technique. Nanoparticles may be formed readily in nature from the available inorganic salts in the presence of antioxidants or polyols.

Nancy Willian, Syukri Syukri, Zulhadjri Zulhadjri, Syukri Arief study by Marine plant mediated green synthesis of silver nanoparticles using mangrove *Rhizophora stylosa*: Effect of variable process and their antibacterial activity. They reported The silver nanoparticles synthesis showed good activity on *Escherichia coli* and Staphylococcus aureus, with an inhibition zone. Currently, most of the natural plants used in the synthesis of silver nanoparticles are limited to terrestrial plants. Only a few studies report the use of marine plants. Indonesia as an archipelago has a wealth of marine resources such as mangroves. Its extracts are known to have antimicrobial abilities that have long been used by the community[47.] One of them is *Rhizophora stylosa* (RS), which is a member of the Rhizophoraceae family in the Southeast Asian mangrove ecosystem. It is known to have several compounds that play an important role in biomedical applications. Some studies report that Rhizophora has several biological activities such as antibacterial, antioxidant and anti-cancer[48,49]. In this study, RS leaf extract was used as a reducing agent in the production of RS-Ag Nps as well as a stabilizer.

CONCLUSION

During the last decades, many efforts were put into the development of new green synthesis methods. plant mediated synthesis and Living organisms of silver nanoparticles possess potential antimicrobial applications. The characterization analysis proved that the particle so produced in nanodimensions would be equally effective as that of antibiotics and other drugs in pharmaceutical applications. Organisms ranging from simple bacteria to highly complex eukaryotes can all be used for the production of nanoobjects with the desired size and shape. Fungi present a suitable option for large-scale green nanoproduction. The use of silver nanoparticles in drug delivery systems might be the future thrust in the field of medicine.

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