Indian Journal of
Advances in Chemical Science

Review Article

A Review on Plant Extract based Silver Nanoparticles and its Applications

Shaista Fatima, Suyashi Mishra, Mahima Mishra, Ekhlakh Veg*

Department of Chemistry, Isabella Thoburn College, Lucknow, India

ABSTRACT

Today, Nanocomposites are synthesized due to their wide applicability in various areas such as cosmetics, food industry, medicine, shampoos, soaps, and detergent. Noble metals such as gold, silver, and platinum nanoparticles (NPs) are traditionally synthesized by wet chemical techniques where the chemicals used are generally toxic and flammable. Now, nanotechnology uses plant extract directly to synthesize Nano composites which are cost-effective and environment friendly. Silver NPs (AgNPs) are easily synthesized by using simply mixing $AgNO_3$ solution with the extract of the plant (leaves, stem, roots, and fruits) which act as reducing as well as capping agent. AgNPs which have been synthesized from different parts of plant extracts showed very good antimicrobial, anti-cancerous and antidiabetic activities.

Key words: AgNP, Plant extract, Nanotechnology

1. INTRODUCTION

The synthesis of nanoparticles (NPs) is picking up significantly throughout the world and the field of nanotechnology has become one of the most dynamic regions of research in material sciences [1]. It is a term for the manufacture or application of structures by controlling their shape and size at the nanoscale, size (1–100 nm), shape, and structure [2,3], Recent applications of NPs are swiftly gaining improvement in several fields such as health care, cosmetics, biomedical, food and feed, drug-gene delivery, environment, health, mechanics, optics, chemical industries, nonlinear optical devices, and photo-electrochemical applications [4]. Methods regarding environmentally friendly synthesis have become famous in chemical synthesis and chemical technologies. As we know, that many chemicals like sodium borohydride or hydrazine and much more hazardous by-products are required and formed in the synthesis of NPs, so a greener route of NP synthesis was explored for over a decade [5]. Nanotechnology applications are highly suitable for biological molecules because they undergo highly controlled assembly, making the synthesis of the metal NP decisive and ecofriendly [5]. Silver NPs (AgNPs) have gained immense popularity in the field of nanotechnology, as it has rare properties such as chemical stability, good conductivity, is catalytic and its amazing immune response when added in food industry, in electronic and cosmetics products, and even in cryogenic superconducting materials [4]. Chemical reduction is one of the most general methods in the bottom-up approach in the synthesis of AgNPs. For the reduction of silver ions, several reducing inorganic and organic agents in aqueous or non-aqueous solutions are used like sodium citrate, Tollen's reagent. For stabilization of the NPs, capping agents were used. A significant amount of NPs was synthesized in a short time, which was one of the major advantages of this method. But this type of synthesis leads to toxic, non-eco-friendly byproducts which promoted the biosynthesis of NPs through the environmentally friendly process. Development of this green synthesis of AgNPs, therefore, was used in the advancement of the branch of nanotechnology through plant extract or plant biomass, microorganisms as an alternative through an eco-friendly way by chemical and physical methods [6]. Biological synthesis involving complex procedures in maintain microbial cultures were overcome by the synthesis of NPs using various plant extracts. Such synthesis was extremely advantageous because plants are widely distributed, easily available, much safer to handle and act as a source of several metabolites. Medicinal plants such as *Oryza sativa*, *Helianthus annus*, *Saccharum officinarum*, *Sorghum bicolor*, *Zea mays*, *Basella alba*, *Aloe vera*, *Capsicum annuum*, were experimentally performed in the synthesis of AgNPs in the field of biological applications and pharmaceutical industries. AgNPs have also been synthesized from naturally occurring sources, and their products like green tea (*Camellia sinensis*), Neem (*Azadirachta indica*), leguminous shrub (*Sesbania drummondii*), various leaf broth, natural rubber, and starch [7]. Thus, this review aims to provide a bio-inspired review involving an eco-friendly, cost-effective synthesis and applications of AgNPs through plants and their extracts.

2. GREEN SYNTHESIS

The environmentally approach of green synthesis of AgNPs using plant extract has gained considerable interest because it is more biocompatible and cost-effective and includes the capability of supporting larger synthesis [8,9]. Chemical synthesis of AgNPs requires mainly three components: (a) silver salt (e.g., $AgNO_3$), (b) a reducing agent (e.g., $NaBH_4$), and (c) a stabilizing or capping agent (e.g., polyvinyl alcohol) for controlling the size of NPs and preventing their aggregation [10]. The availability, safety in handling, and presence of variability of metabolites that may aid in reducing silver are some of the advantages of using plants for the synthesis of NPs. The time required to reduce 90% of silver ions is approximately

***Corresponding author:**
E-mail: akhlakhbeg123@gmail.com

ISSN NO: 2320-0898 (p); 2320-0928 (e)
DOI: 10.22607/IJACS.2021.904010

Received: 08th October 2021;
Revised: 02nd November 2021;
Accepted: 02nd November 2021

2–4 h [11]. Natural extracts are used to reduce silver ions (Ag^+) into silver NPs (Ag^0), during the biological synthesis, due to the presence of phytochemical compounds such as polysaccharides, polyphenolic compounds, vitamins, amides, alkaloids, terpenoids tannin, organic acids, and aromatic dicarboxylic acids in it [12]. Leaf extract of *C. annuum* contain a number of biomolecules, such as proteins, enzymes, polysaccharides, amino acids, and vitamins, which could act as bioreductants for metal ions or as a platform to direct the formation of AgNPs in solution. The trapping of silver ions occurred in bio reduction of silver, on the surface of proteins in the extract via electrostatic interactions (i.e., recognition process). Silver ions were then reduced by proteins, leading to changes in their secondary structure with the formation of silver nuclei which subsequently grew by the further reduction of silver ions and their accumulation at nuclei [13]. Stem methanolic extract of *Callicarpa maingayi* was used for the synthesis of AgNPs, leading to the formation of [Ag (*C. maingayi*)] + complex. Reduction of silver ions into metallic AgNPs is due to the aldehyde groups present in plant extract. –C = 0, C = N functional group indicates amide I of polypeptides that are responsible for the capping of ionic substances into metallic NPs [14].

3. APPLICATIONS

There is a wide array of applications of AgNPs from their antimicrobial, anti-cancerous properties to their several environmental applications.

4. ANTIMICROBIAL ACTIVITY

Recently, biogenic AgNPs have demonstrated remarkable antibacterial effects as reported by several investigators. AgNPs synthesized using *A. vera*, *Portulaca oleracea*, and *Cynodon dactylon*, showed antibacterial activity of AgNPs due to rupture of the cell wall. High antibacterial activity was reported in AgNPs synthesized by medicinal plant extracts [30]. AgNPs (4–30 nm) prepared using *Ocimum sanctum* (Tulsi) leaf extract showed antibacterial effect on Gram-negative. *Escherichia coli* and Gram-positive *Staphylococcus aureus* [31]. Similarly, an antibacterial effect against waterborne pathogens, viz., *E. coli,* and *Vibrio cholera* was seen by biosynthesized AgNPs using *Acalypha indica* leaf extracts [32]. From *Salvadora persica L.* root extract, AgNPs showed antibacterial effect in bacterial strains in both Gram negative and Gram-positive bacteria [33]. Kaviya *et al*. prepared AgNPs using *C. sinensis* peel extract and evaluated their antibacterial effect on Gram-negative *E. coli* and *Pseudomonas aeruginosa*, and Gram-positive *S. aureus* bacteria. *Artemisia vulgaris* leaves extract (AVLE) have been used to synthesize AgNPs without adding any other capping potential. AVLE showed exceptional antimicrobial properties against pathogens, when diagnosed against five different human pathogenic bacteria, *E. coli*, *S. aureus*, *P. aeruginosa*, *Klebsiella pneumoniae*, and *Haemophilus influenza* as the cytotoxic effect of AgNPs on human epithelial cells revealed considerable inhibition activities against all the examined pathogens. From the root of the ginger plant extract, the synthesized AgNPs proved their antimicrobial activity against food pathogens of *Staphylococcus* spp., *Listeria* spp. and *Bacillus* spp as ginger is rich in antioxidants [34].

5. ANTIDIABETIC ACTIVITY

Synthesis of AgNPs using stem extracts of *Tephrosia tinctoria* showed the ability to control blood sugar levels. The particles around the free radicals caused decrease in levels of enzymes that catalyze the hydrolysis of complex carbohydrates (α-glucosidase and α-amylase), and increased the consumption rate of glucose [35].

6. ANTI-CANCEROUS ACTIVITY

Biosynthesized AgNPs anti-cancerous effect suggests their future role as therapeutic agents to combat cancer. It was found that the major reason for the cytotoxic effect of biosynthesized AgNPs was generation of reactive oxygen species and these particles were responsible to sensitize cancer cells, making them cisplatin-resistant [36]. AgNPs synthesized from plant extract of *Alternanthera sessilis*, exhibited significant cytotoxic activity toward prostate cancer cells (PC-3) [37]. Dual activity of biologically synthesized AgNPs was also found through plant extract of *Origanum vulgare* (oregano), exhibiting antibacterial and anticancer activity [38]. Similarly, biofabricated AgNPs using *Sterculia foetida L.* seed extract, exhibited not only enhanced killing ability toward human cervical cancer cell lines but also antiangiogenic activity of biosynthesized AgNPs [39].

Plant	Part of plant	Size (nm)	Shape
Emblica officinalis [15]	Leaf	10-20	Spherical
Calotropis procera [16]	Plant	19-45	Spherical
Aloe vera [11]	Stem	50-350	Spherical, Triangle
Allium sativum [17]	Leaf	4-22	Spherical
Banana [18]	Peel extract	23.7	Spherical
Zingiber officinale [19]	Rhizome	3.1	Spherical
Hibiscusrosa sinensis [20]	Leaf	14	Spherical
Cuminum cyminum [21]	Seeds powder	12	Spherical
Syzygium cumini [22]	Bark extract	20-60	Spherical
Solanum tuberosum [23]	Potato infusion	10-12	Spherical
Termination arjuna [24]	Bark extract	2-100	Spherical
Thevetia peruviana [25]	Latex extract	10-20	Spherical
Carica papaya [26]	Fruit extract	15	Cubic
Lantana camara [27]	Fruit extract	12.55-12.99	Spherical
Tagetes erecta [28]	Flower broth	10-90	Spherical
Catharanthus roseus [29]	Root extract	35–55	Spherical

7. OTHER APPLICATIONS

Antiviral activity against HIV-1 at non-cytotoxic concentrations exerted by AgNPs was shown but their mechanism has not been fully elucidated [40]. AgNPs synthesized from an aqueous plant extract of *Allium cepa* (garlic) and *Allium sativum* (onion) showed pathogenic and antiseptic activity against some Gram-positive and Gram-negative vaginal bacteria such as *S. aureus* and *P. aeruginosa* [41]. Interaction of AgNPs from *Solanum tuberosum* extract with human serum albumin leads to the "corona" formation (formation of particles with different properties). Interaction of PE extract plasma protein HAS with AgNPs can transport drugs and is effective in drug delivery systems [42]. In the expanding field of nanotechnology, silver appears in many consumer computer's keyboard, clothing, and deodorizing sprays. AgNPs have shown great catalytic activities in dye reduction (reduction of methylene blue by arsine in presence of AgNPs). Synthesis of AgNPs using aqueous *Piper longum* fruit extract showed powerful antioxidant properties *in vitro* antioxidant assays [4]. The synthesis of AgNPs from plant extracts has shown remarkable applications in agro-based industry. Food and Agricultural Organization and World Health Organization in June 2009 in joint venture proclaimed nanotechnological food and agricultural applications ranging from food packaging to nanocoating and nanofiltration. NPs have been used for the development of nano pesticides and nano fertilizers. The particle size of NPs ranging from 100 to 250 nm has been widely used in agro-industries by increasing their solubility and their activity [43]. AgNPs are used in cardiovascular implants, in which silver element is coated in the cardiovascular device in prosthetic silicone heart to avoid bacterial contamination and reduce inflammation of the heart. AgNPs in nanocomposites even showed anti-thrombogenic and antibacterial properties in heart valves and stents. AgNPs have also shown protection from contamination and complications in catheters when coated on them. Even polyurethane catheters coated with AgNPs made powerful antibacterial catheters. The use of AgNPs in wound dressings reduced the therapeutic time of injury by the standard of 3.35 days as compared to silver sulfadiazine and gauze dressing. Chitin AgNPs showed antibacterial potential for wound dressings. Orthopedic and orthodontic implants with the incorporation of AgNPs reduced bacterial contamination and provided a safe connection of hip and knee prostheses surgery. Even incorporation of AgNPs in dental composites reduced microbial colonization of coating materials and improved antifungal proficiency. NPs in fabrics have shown increment in the strength of material capacities. AgNPs have been used to produce towels, furniture materials, kitchen fabrics, self-cleaning, bed lines or reusable surgical gloves, patient, suits against biohazards, restorative items, ultra-hydrophobic fabrics, sportswear, and potential applications in the generation of profoundly water-repulsive materials. NPs have shown exceptional behavior in biosensors because of their detection by optic absorption fluorescence and electric conductivity and many more. Nano biosensors have been used for the diagnosis of diseases, cell tracking, imaging, or therapy monitoring [6]. In field of nanotechnology, AgNPs have shown a variety of potential applications like antibacterial, antifungal, and even anti-cancerous.

8. CONCLUSION

This review article provides a brief overview of the properties and the potential application of green synthesis of AgNPs which have good antimicrobial, anti-cancerous and antidiabetic properties. Various plant species and plant parts in tabular form enlisted reveal that they are successfully deployed to synthesize AgNPs due to the presence of an extensive range of bio-active compounds such as carbohydrates, alkaloids, terpenoids, phenolic compounds, and enzymes. In all the promising applications of biologically synthesized AgNPs in daily life, more research is required to unknot long-term chemical and physical properties and to overcome the toxicity of bio-synthesized AgNPs [44]. Thus, a greener route for AgNPs in the field of nanotechnology will make an immense impact in the coming decade.

REFERENCES

1. V. Sarsar, K. K. Selwal, K. Selwal, (2013) Green synthesis of silver nanoparticles using leaf extract of *Mangifera indica* and evaluation of their antimicrobial activity, ***Journal of Microbiology and Biotechnology Research***, **3:** 27-32.
2. W. Jahn, (1999) Review: Chemical aspects of the use of gold clusters instructural biology, ***Journal of Structural Biology***, **127:** 106-112.
3. R. M. Slawson, J. T. Trevors, H. Lee, (1992) Silver accumulation and resistance in *Pseudomonas stutzeri*, ***Archives of Microbiology***, **158:** 398-404.
4. S. Ahmed, M. Ahmad, B. L. Swami, S. Ikram, (2016) A review on plants extract mediated synthesis of silver nanoparticles for antimicrobial applications: A green expertise, ***Journal of Advanced Research***, **7**(**1**): 17-28.
5. P. Rauwel, S. Küünal, S. Ferdov, E. Rauwel, (2015) A review on the green synthesis of silver nanoparticles and their morphologies studied via TEM, ***Advances in Materials Science and Engineering***, **2015:** 682749.
6. M. Rafiquea, I. Sadafb, M. S. Rafiquea, M. B. Tahir, (2017) A review on green synthesis of silver nanoparticles and their applications, ***Artificial Cells, Nanomedicine, and Biotechnology***, **45:** 1272-1291.
7. G. Geoprincy, B. N. V. Srri, U. Poonguzhali, N. N. Gandhi, S. Renganathan, (2013) A review on green synthesis of silver nanoparticles, ***Asian Journal of Pharmaceutical and Clinical Research***, **6**: 8-12.
8. K. D. Arunachalam, S. K. Annamalai, S. Hari, (2013) One-step green synthesis and characterization of leaf extract-mediated biocompatible silver and gold nanoparticles from *Memecylon umbellatum*, ***International Journal of Nanomedicine***, **8:** 307-315.
9. A. K. Mittal, D. Tripathy, A. Choudhary, P. K. Aili, A. Chatterjee, I. P. Singh, U. C. Banerjee, (2015) Bio-synthesis of silver nanoparticles using *Potentilla fulgens* Wall. ex Hook. and its therapeutic evaluation as anticancer and antimicrobial agent. ***Materials Science and Engineering C: Materials for Biological Applications***, **53:** 120-127.
10. D. M. Ledwith, A. M. Whelan, J. M. Kelly, (2007) A rapid, straight-forward method for controlling the morphology of stable silver nanoparticles, ***Journal of Materials Chemistry***, **17:** 2459-2464.
11. S. P. Chandran, M. Chaudhary, R. Pasricha, A. Ahmad, M. Sastry, (2006) Synthesis of gold nanotriangles and silver nanoparticles using *Aloe vera* plant extract, ***Biotechnology Progress***, **22**(**2**): 577-583.
12. M. Heinlaan, A. Ivask, I. Blinova, H. C. Dubourguier, A. Kahru, (2008) Toxicity of nanosized and bulk ZnO, CuO and TiO_2 to bacteria *Vibrio fischeri* and crustaceans *Daphnia* magna and *Thamnocephalus platyurus*. ***Chemosphere***, **71:** 1308-1316.
13. S. Li, Y. Shen, A. Xie, X. Yu, L. Qiu, L. Zhang, Q. Zhang, (2007) Green synthesis of silver nanoparticles using *Capsicum annuum* L. extract, *Green Chemistry*, **9:** 852-858.
14. K. Shameli, M. Ahmad, E. A. J. Al-Mulla, N. A. Ibrahim, P. Shabanzadeh, A. Rustaiyan, Y. Abdollahi, S. Bagheri, S.

Abdolmohammadi, M. S. Usman, M. Zidan, (2012) Green biosynthesis of silver nanoparticles using *Callicarpa maingayi* stem bark extraction, ***Molecules***, **17:** 8506-8517.

15. B. Ankamwar, C. Damle, A. Ahmad, M. Sastry, (2005) Biosynthesis of gold and silver nanoparticles using *Emblica officinalis* fruit extract, their phase transfer and transmetallation in an organic solution, ***Journal of Nanoscience and Nanotechnology***, **5(10)**: 1665-1671.
16. M. Gondwal, G. J. N. Pant. (2013) Biological evaluation and greensynthesis of silver nanoparticles using aqueous extract of *Calotropis procera*, ***International Journal of Pharma and Bio Sciences***, **4(4)**: 635-643.
17. M. Ahamed, M. Khan, M. Siddiqui, M. S. AlSalhi, S. A. Alrokayan, (2011) Green synthesis, characterization and evaluation of biocompatibility of silver nanoparticles, ***Physica E: Low-dimensional Systems and Nanostructures***, **43:** 1266-1271.
18. H. M. Ibrahim, (2015) 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***, **8:** 265-275.
19. T. I. Shalaby, O. A. Mahmoud, G. A. El Batouti, E. E. Ibrahim, (2015) Green synthesis of silver nanoparticles: Synthesis, characterization and antibacterial activity. ***Journal of Nanoscience and Nanotechnology***, **5:** 23-29.
20. D. Philip, (2010) Green synthesis of gold and silver nanoparticles using *Hibiscus rosa sinensis*, ***Physica E: Low-dimensional Systems and Nanostructures***, **42:** 1417-1424.
21. K. R. Kudle, M. R. Donda, J. Alwala, R. Koyyati, V. Nagati, R. Merugu, Y. Prashanthi, M. Rudra, (2012) Biofabrication of silver nanoparticles using *Cuminum cyminum* through microwave irradiation, ***International Journal of Nanomaterials and Biostructures***, **2:** 65-69.
22. R. Prasad, V. S. Swamy, (2013) Antibacterial activity of silver nanoparticles synthesized by bark extract of *Syzygium cumini*, ***Journal of Nanoparticles***, **2013:** 431218.
23. K. Roy, C. Sarkar, C. Ghosh, (2015) Photocatalytic activity of biogenic silver nanoparticles synthesized using potato (*Solanum tuberosum*) infusion, ***Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy***, **146:** 286-291.
24. Q, Ahmed, N, Gupta, A, Kumar, S. Nimesh, (2016) Antibacterial efficacy of silver nanoparticles synthesized employing *Terminalia arjuna* bark extract, ***Artificial Cells, Nanomedicine, and Biotechnology***, **45(6)**: 1-9.
25. N. N. Rupiasih, A. Aher, S. Gosavi, P. B. Vidyasagar, (2015) Green synthesis of silver nanoparticles using latex extract of *Thevetia peruviana*: A novel Artificial cells, nanomedicine and biotechnology 1289 approach towards poisonous plant utilization. In: ***Recent Trends in Physics of Material Science and Technology***, Berlin: Springer, p110.
26. D. Jain, H. K. Daima, S. Kachhwaha, S. Kothari, (2009) Synthesis of plant-mediated silver nanoparticles using papaya fruit extract and evaluation of their anti-microbial activities, ***Digest Journal of Nanomaterials and Biostructures***, **4:** 557-563.
27. P. Sivakumar, C. Nethradevi, S. Renganathan, (2012) Synthesis of silver nanoparticles using Lantana camara fruit extract and its effect on pathogens, ***Asian Journal of Pharmaceutical and Clinical Research***, **5:** 97-101.
28. H. Padalia, P. Moteriya, S. Chanda, (2015) Green synthesis of silver nanoparticles from marigold flower and its synergistic antimicrobial potential, ***The Arabian Journal of Chemistry***, **8:** 732-741.
29. T. Rajagopal, I. A. A. Jemimah, P. Ponmanickam, M. Ayyanar, (2015) Synthesis of silver nanoparticles using Catharanthus roseus root extract and its larvicidal effects, ***Journal of Environmental Biology***, **36:** 1283.
30. T. A. Abalkhil, S. A. Alharbi, S. H. Salmen, M. Wainwright, (2017) Bactericidal activity of biosynthesized silver nanoparticles against human pathogenic bacteria, ***Biotechnology and Biotechnological Equipment***, **31:** 411-417.
31. G. Singhal, R. Bhavesh, K. Kasariya, A. R. Sharma, R. P. Singh, (2011) Biosynthesis of silver nanoparticles using *Ocimum sanctum* (Tulsi) leaf extract and screening its antimicrobial activity, ***Journal of Nanoparticle Research***, **13:** 2981-2988.
32. C. Krishnaraj, E. G. Jagan, S. Rajasekar, P. Selvakumar, P. T. Kalaichelvan, N. Mohan, (2010) Synthesis of silver nanoparticles using Acalypha indica leaf extracts and its antibacterial activity against water borne pathogens, ***Colloids and Surfaces B: Biointerfaces***, **76:** 50-56.
33. R. M. Shaik, G. Albalawi, S. Khan, M. Khan, S. Adil, M. Kuniyil, A. Al-Warthan, M. R. H. Siddiqui, H. Z. Alkhathlan, M. Khan, (2016) Miswak based green synthesis of silver nanoparticles: Evaluation and comparison of their microbicidal activities with the chemical synthesis, ***Molecules***, **21:** 1478.
34. P. Velmurugan, K. Anbalagan, M. Manosathyadevan, K. J. Lee, M. Cho, S. M. Lee, J. H. Park, S. G. Oh, K. S. Bang, B. T. Oh, (2014) Green synthesis of silver and gold nanoparticles using *Zingiber officinale* root extract and antibacterial activity of silver nanoparticles against food pathogens, ***Bioprocess and Biosystems Engineering***, **37(10)**: 1935-1943.
35. K. Rajaram, D. C. Aiswarya, P. Sureshkumar, (2015) Green synthesis of silver nanoparticle using *Tephrosia tinctoria* and its antidiabetic activity, ***Materials Letters***, **138:** 251-254.
36. L. Fageria, V. Pareek, R. V. Dilip, A. Bhargava, S. S. Pasha, I. R. Laskar, H. Saini, S. Dash, R. Chowdhury, J. Panwar, (2017) Biosynthesized protein-capped silver nanoparticles induce ROS-dependent proapoptotic signals and Prosurvival autophagy in cancer cells, ***ACS Omega***, **2:** 1489-1504.
37. M. J. Firdhouse, P. Lalitha, (2013) Biosynthesis of silver nanoparticles using the extract of *Alternanthera sessilis*-antiproliferative effect against prostate cancer cells, ***Cancer Nanotechnology***, **4:** 137-143.
38. R. Sankar, A. Karthik, A. Prabu, S. Karthik, K. S. Shivashangari, V. Ravikumar, (2013) *Origanum vulgare* mediated biosynthesis of silver nanoparticles for its antibacterial and anticancer activity, ***Colloids and Surfaces B: Biointerfaces***, **108:** 80-84.
39. P. Rajasekharreddy, P. U. Rani, (2014) Biofabrication of Ag nanoparticles using L. seed extract and their toxic potential against mosquito vectors and HeLa cancer cells, ***Materials Science and Engineering C: Materials for Biological Applications***, **39:** 203-212.
40. S. M. Mousavi, S. A. Hashemi, Y. Ghasemi, A. Atapour, A. M. Amani, A. S. Dashtaki, A. Babapoor, O. Arjmand, (2018) Green synthesis of silver nanoparticles toward bio and medical applications: Review study, ***Artificial Cells, Nanomedicine, and Biotechnology***, **46(sup3)**: S855-S872.
41. N. A. Bouqellah, M. M. Mohamed, Y. Ibrahim, (2019) Synthesis of eco-friendly silver nanoparticles using *Allium* sp. and their antimicrobial potential on selected vaginal bacteria, ***Saudi Journal of Biological Sciences***, **26(7)**: 1789-1794.
42. M. P. Monopoli, C. Åberg, A. Salvati, K. A. Dawson, (2012)

Biomolecular coronas provide the biological identity of nanosized materials, ***Nature Nanotechnology***; **7:** 779-786.

43. L. Castillo-Henríquez, K. Alfaro-Aguilar, J. Ugalde-Álvarez, L. Vega-Fernández, G. M. de Oca-Vásquez, J. R. Vega-Baudrit, (2020) Green synthesis of gold and silver nanoparticles from plant extracts and their possible applications as antimicrobial agents in the agricultural area, ***Nanomaterials*** (***Basel***), **10**(**9**): 1763.
44. M. Ijaz, M. Zafar, T. Iqbal, (2021) Green synthesis of silver nanoparticles by using various extracts: A review, ***Inorganic and Nano-Metal Chemistry***, **51:** 744-755.

***Bibliographical Sketch**

Shaista Fatima, MSc. final year pursuing from Department of Chemistry, Isabella Thoburn College, Lucknow.

Shaista Fatima, MSc. final year pursuing from Department of Chemistry, Isabella Thoburn College, Lucknow.

Mahima Mishra, MSc. final year pursuing from Department of Chemistry, Isabella Thoburn College,Lucknow.

Ekhlakh Veg, MSc., Assistant professor, Department of Chemistry, Isabella Thoburn College Lucknow. He has been teaching since 5 years at Isabella Thoburn College Lucknow. His area of research interests nanomaterials, coordination chemistry.