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BULK TO NANOSIZED PARTICLES BY GREEN MOLECULAR SURFACTANTS FROM PLANT BASED PRODUCTS

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Abstract

Using plant extracts to synthesize metal nanoparticles is one of the easiest, most practical, affordable, and eco-friendly ways to reduce the use of hazardous chemicals. Therefore, employing aqueous extracts of plant parts like leaves, bark, roots, etc., numerous environmentally acceptable methods for the quick synthesis of silver nanoparticles have been discovered in recent years. This review covers the literature from 2015 and provides an overview of the latest research on the green synthesis of silver nanoparticles (AgNPs) utilizing various plant extracts and their possible uses as antimicrobial agents.

We aim to provide a systematic, in-depth discussion on the potential influences of phytochemicals and their concentrations in plant extracts, extraction solvent, and extraction temperature; as well as reaction temperature, pH, reaction time, and precursor concentration on the size, shape, and stability of the produced AgNPs, while highlighting the various plants that have recently been used to synthesize highly effective antimicrobial green AgNPs. Complete explanations of the conceivable process by which AgNPs interact with microbial cell walls to cause cell death and strong antibacterial activity have also been developed. Comprehensive details have also been provided regarding the improved antibacterial activities resulting from the synergistic interaction of AgNPs with commercial antibiotic medicines, as well as the shape and size-dependent antimicrobial activities of the biogenic AgNPs.

INTRODUCTION

A review on Phytochemical mediated synthesis of nano sized materials as a new field of study focused on creating nanomaterials and nanoparticles (NPs) for use in a variety of industries, including food technology, electrochemistry, biomedicine, pharmaceuticals, sensors, and catalysis, nanotechnology is garnering a lot of attention.[1-3] Depending on their size and form, nanoparticles (NPs) are solid, nanometer-sized (<100 nm) atomic or molecular particles with superior physical properties over bulk molecules.[4,5] Since metal and metal oxide nanoparticles have such good qualities as a high surface to volume ratio and great dispersion in solution, among other advantages, they have been the subject of much scientific and technological investigation among all other types of NPs.[6,7]These are the reasons why metal and metal oxide nanoparticles have improved antibacterial capabilities.[8,9]

COMPOSITION OF THE PLANT EXTRACT

Plant parts like leaves, roots, flowers, fruits, rhizomes, and so on have all been effectively used to synthesize AgNPs. [10–11] Plant parts are gathered from several sources and thoroughly cleaned with regular and distilled water to remove any undesired materials or trash. Subsequently, the pieces are either used fresh to manufacture the extract or dried and pulverized to make powder. The chopped plant parts or crushed powder are added to deionized water or alcohol to make the extract. The mixture is then heated below 60 degrees Celsius for a few hours, as prolonged high temperatures can cause the phytochemicals in the biomass extract to break down.

AgNPs are created by adding plant extract with varying pH values to solutions with varying concentrations of Ag salt as the metal precursor, then heating the mixture at varying temperatures.[12–13] Because the extract's biomaterials serve as both a reducing and stabilizing agent for the creation of AgNPs, this synthesis method avoids the need for chemical stabilizers.[14, 15] AgNPs can be visually seen for color changes, or their creation can be tracked with UV-Vis Spectroscopy, which shows a distinct sharp peak at about 430–450 nm that is caused by the AgNPs' surface plasmon resonance (SPR) noted.[16] Following the effective synthesis of the AgNPs, the mixture is dried in a low-temperature oven and centrifuged at high rpm to separate the NPs. Proper washing with solvents is then performed.[17, 18] Fig. lists the many plant part extracts that have been effectively used in the green synthesis of AgNPs.

Fig. Different parts of plants used for biosynthesis of antimicrobial Silver nanoparticles.

SYNTHESIS FROM LEAVES

Many leaf extracts have been used up to this point in the biosynthesis of AgNPs. It was reported that Skimmia laureola could synthesize spherical AgNPs with a size of 38.27 nm, which were then tested against S. aureus, P. vulgaris, P. aeruginosa, K. pneumoniae, and E. coli.[19] Prosopis farcta extract was employed by Miri et al. [20] to produce AgNPs that have an average size of 10.8 nm at room temperature (RT). Using the disc diffusion method, the antimicrobial activity of synthesized AgNPs was evaluated against Gram-positive (Staphylococcus aureus, PTCC 1431), Gram-negative (Escherichia coli, PTCC 1399), and Pseudomonas aeruginosa, PTCC 1074) bacteria and compared with the control. The findings demonstrated that the inhibitory diameter increased for each pathogen that was examined, suggesting that artificially generated AgNPs cause bacterial cellular damage and can therefore be employed as nanoantibiotics.To produce spherical biogenic AgNPs, other plants such as aloe vera, Eclipta alba, Momordica charantia, Leptadenia reticulata, and others are also utilized (21). In a different work, tea leaf extract was used to create AgNPs. When the synthesized NPs were tested for bactericidal activity against S. aureus and E. coli, the results indicated that the inhibition action against S. aureus was more successful (89% inhibition rate) than it was against E. coli (75% inhibition rate). Additionally, bacterial cell-cell attachment is hampered by the treatment of the NPs against the bacteria.[22]

SYNTHESIS FROM SEEDS

Additionally well-established for the manufacturing of nanoparticles is plant seed extract. Various seed extracts have been used up to this point for the biosynthesis of AgNPs. AgNPs mediated by Sinapis arvensis seeds have been shown to limit the growth of N. parvum mycelium by over 83%. Within 50 days of the process, an investigation using inductively coupled plasma spectrometry (ICP) showed that Ag^+ had completely reduced to Ag^0, with a conversion rate of over 95%. Reference [23] In a different study, grape seed extract was used to biosynthesize polygonal and spherical AgNPs that have a diameter of 25–35 nm.

The synthesized NPs' bactericidal activity was evaluated against eight distinct ocean pathogenic bacteria; however, only four of them, namely V. alginolyticus, V. anguilla tis, V. parahaemolyticus, and A. punctate, demonstrated significant inhibitory activity.[24] Durio zibethinus seed extract was used in the bio-reduction of $AgNO_3$ to AgNPs, as reported by Sumitha et al. [25]. It has been observed that the extract's amino acids stabilized the produced AgNPs and that the extract's saccharides induced bio-reduction. When tested against various harmful bacteria, the NPs' bactericidal activity was found to be more effective against S. typhimurium, S. haemolyticus, and S. aureus than against B. subtilis, E. coli, and S. typhi. But in contrast to the medication Gentamicin, the synthetic NPs shown decreased inhibition against all the even at a lesser dose of Gentamicin, harmful microorganisms were mentioned. Pimpinella anisum, Synsepalum dulcificum, Vigna radiate, Dracocephalum moldavica, and Vigna radiate [26–27]. Leaf extracts [28] were also successfully used in the environmentally friendly synthesis of AgNPs. AgNPs mediated by Vigna radiata were found to be less susceptible to destruction by AgNPs when applied to Gram-negative bacteria, such as E. coli (ZOI 20 mm), than to Gram-positive bacteria, such as S. aureus (ZOI 16 mm). This is because the peptidoglycan layer of Gram-positive bacteria's cell wall is approximately 80 nm thick, ten times thicker than that of Gram-negative bacteria.[27]

SYNTHESIS FROM FLOWERS

Recently, the biosynthesis of NPs has made extensive use of flower extracts. The bio-reduction of $AgNO_3$ to AgNPs is covered in a number of literatures. In order to create AgNPs and study their bactericidal activity against both Gram-positive and Gram-negative bacteria like S. aureus, B. cereus, S. coli, P. aeruginosa, C. glabrata, C. albicans, and C. neoformans, Padalia et al. [29] reported using Tagetes erecta flower extract for the bio-reduction of $AgNO_3$. The outcome showed that, in comparison to other pathogenic bacteria, E. Coli and

P. aeruginosa have higher bactericidal activity. In addition, the scientists noted that when compared to antibiotics alone, the antifungal activity of AgNPs in combination with antibiotics shown remarkable action against the fungal strain and Gramnegative bacteria.

Plant extracts from the manufacture of biogenic AgNPs, including those of Nyctanthes arbortristis, Caesalpinia pulcherrima, Alcea rosea, and Argemone Mexicana, have also been reported. Tecoma stans flower extract was used to create spherical AgNPs that ranged in size from 50 to 60 nm through biosynthesis. Testing for antimicrobial activity against S. aureus and E. coli revealed that the former's ZOI (24 mm) is greater than that of the latter (16 mm).[30] Ultra-small AgNPs produced by Moringa oleifera demonstrated a high ZOI of 29 mm against S. aureus.194 Probably because of its small size, this is one of the highest ZOIs employing biogenic AgNPs that have been seen at this concentration thus far. The increased antibacterial activity of the AgNPs in Gram positive bacteria is another intriguing discovery in this work bacteria (S. aureus) as opposed to the uncommon Gram-negative one (K. pneumonia). Ajitha et al. reported in a different study that they used Syzygium aromaticum flower extract as a capping agent and as a bio-reducing agent in the manufacture of polydisperse AgNPs. The synthesized NPs' antimicrobial activity was investigated against a variety of microorganisms, and it was discovered that Pseudomonas species exhibits the highest level of NP-induced bacterial strain cell disruption.[31]

SYNTHESIS FROM ROOTS

These days, there is a lot of interest in the environmentally friendly synthesis of AgNPs and their use as antimicrobials via plant root extract. Potentilla fulgens root extract was found to be a strong antibacterial agent against B. subtilis and E. coli, with ZOI values of 9.7 + 0.6 and 9.5 + 0.2, respectively.[32] Alpinia calcarata root extract has recently been used in the green synthesis of spherical AgNPs as a stabilizing and bio-reducing agent. Tests for antimicrobial efficacy against P. mirabilis, E. coli, B. cereus, and S. aureus revealed that produced AgNPs aided by Alpinia calcarata root extract have a high potential for inducing bacterial strain cell disruption. The produced AgNPs is stable for a maximum of six months aside from that.[33]

Additionally, it has been shown that the root extracts of Erythrina indica L. [34], Diospyros paniculate [35], and Diospyros sylvatica create AgNPs with microbial activity.[36] Using Annona muricata Linn root bark extract, Ezealisiji et al. have reported the green synthesis of AgNPs and explored their potential use as an antibacterial agent against pathogenic bacteria, including B. subtilis, S. aureus, K. pneumonia, E. coli, and Pseudomonas aeruginosa. At a dose of 5 mg/mL1, the diameters of the zone of inhibition (ZOI) for each of the five pathogens were 10.00, 15.00 mm and 12.50, 17.50, and 20.00 mm, respectively.At 12.50, 14.50 mm and 14.00, 18.50, and 26.00 mm, respectively, the ZOI is raised.

A dosage of 10 mgmL of AgNPs 1. Considering this, the authors have stated that AgNPs' bactericidal action varies with concentration.[37]

SYNTHESIS FROM BARK

Bark extract has been extensively used as a stabilizing and reducing agent for the environmentally friendly synthesis of AgNPs in recent years. By employing different plant bark extracts, including those from Afzelia quanzensis, Syzygium alternifolium, and Cochlospermum religiosum, green synthesis of AgNPs with antibacterial activity was achieved.[38] Nayak et al. [39] have reported employing bark extract from Ficus benghalensis and Azadirachta indica to create AgNPs that are green and measure 90.13 nm in size. When the synthesized AgNPs were examined for their bactericidal action against both Gram-positive and Gram-negative bacteria, including E. Coli, P. aeruginosa, V. cholera, and B. subtilis, it was found that the synthetic AgNPs had a significant potential for inhibition against these bacterial diseases.

According to the authors, the phytochemicals surrounding the artificially generated AgNPs give them a distinctive surface feature, which makes them capable of harming different types of cell membranes. Aside from that, various plant bark extracts were also used for the green synthesis of AgNPs and to examine their antimicrobial activity against different bacterial strains. These extracts included Plumbago zey lanica,[40] Helicteres isora, [41] Terminalia arjuna, [42] Butea mono sperma, [43] Prosopis juliflora, [44] Garcinia mangostana, and Solanum trilobatum [45]. The bark extract of Butea monosperma is said to be ineffective for any ZOI; nonetheless, at extremely low concentrations, the extract-mediated AgNPs showed excellent ZOI.

$AgNO_3$ solution produces a higher ZOI than AgNPs, however it needs a high concentration, which is bad for the user. Conversely, a very tiny concentration of AgNPs demonstrated strong ZOI against the bacterial strains, meaning that they might be applied as a therapy.[43]

REFERENCES

M. Ayel′ en V′ elez, M. Cristina Perotti, L. Santiago, A. Mar′ ıa Gennaro and E. Hynes, Bioactive compounds delivery using nanotechnology: design and applications in dairy food, Elsevier Inc., 2017.

A. Bera and H. Belhaj, J. Nat. Gas Sci. Eng., 2016, 34, 1284 1309.

L. J. Frewer, N. Gupta, S. George, A. R. H. Fischer, E. L. Giles and D. Coles, Trends Food Sci. Technol., 2014, 40, 211–225.

V. J. Mohanraj and Y. Chen, Trop. J. Pharm. Res., 2007, 5, 561–573.

L. Stadler, M. Homafar, A. Hartl, S. Naja□shirtari, R. Zbo, M. Petr, M. B. Gawande, J. Zhi and O. Reiser, ACS Sustainable Chem. Eng., 2019, 7, 2388–2399.

M. D. Purkayastha and A. K. Manhar, Nanosci. Food Agri., 2016, 2,59–128.

S. Chatterjee, Dhanurdhar and L. Rokhum, Renewable Sustainable Energy Rev., 2017, 72, 560–564.

S. Bagheri and N. M. Julkapli, J. Magn. Magn. Mater., 2016, 416, 117–133.

A.P.Ingle, A. Biswas, C. Vanlalveni, R. Lalfakzuala, I. Gupta, P. Ingle, L. Rokhum and M. Rai, Microb. Bionanotechnol., 2020, 135–161.

A. Ahmad,Y.Wei,F. Syed, K. Tahir, A. U. Rehman, A. Khan, S. Ullah and Q. Yuan, Microb. Pathog., 2017, 102, 133–142.

S. Vanaraj, B. B. Keerthana and K. Preethi, J. Inorg. Organomet. Polym. Mater., 2017, 27, 1412–1422.

S. M. Ali, N. M. H. Yousef and N. Nafady, J. Nanomater., 2015, 1–10.

B. Ajitha, Y. Ashok Kumar Reddy, S. Shameer, K. M. Rajesh, Y. Suneetha and P. Sreedhara Reddy, J. Photochem. Photobiol., B, 2015, 194,84–92.

R. Manikandan, B. Manikandan, T. Raman, K. Arunagirinathan, N. M. Prabhu, M. Jothi Basu, M. Perumal, S. Palanisamy and A. Munusamy, Spectrochim. Acta, Part A, 2015, 138, 120–129.

A. Biswas, C. Vanlalveni, P. P. Adhikari, R. Lalfakzuala and L. Rokhum, IET Nanobiotechnol., 2018, 12, 933–938.

C. Vanlalveni, K. Rajkumari, A. Biswas, P. P. Adhikari, R. Lalfakzuala and L. Rokhum, Bionanoscience, 2018, 8, 624–631.

T. Kokila, P. S. Ramesh and D. Geetha, Appl. Nanosci., 2015, 5, 911–920.

V. Kathiravan, S. Ravi, S. Ashokkumar, S. Velmurugan, K. Elumalai and C. P. Khatiwada, Spectrochim. Acta, Part A, 2015, 139, 200–205.

M. J. Ahmed, G. Murtaza, A. Mehmood and T. M. Bhatti, Mater. Lett., 2015, 153,10–13.

A. Miri, M. Sarani, M. Rezazade Bazaz and M. Darroudi, Spectrochim. Acta, Part A, 2015, 141, 287–291.

S. Ahmed and S. Ikram, Nano Res. Appl., 2015, 1,1–6.

S. R. Goswami, T. Sahareen, M. Singh and S. Kumar, J. Ind. Eng. Chem., 2015, 26,73–80.

M. Khatami, S. Pourseyedi, M. Khatami, H. Hamidi, M. Zaei□ and L. Soltani, Bioresour. Bioprocess., 2015, 2, 19.

H. Xu, L. Wang, H. Su, L. Gu, T. Han, F. Meng and C. Liu, Food Biophys., 2014, 10,12– 18.

S. Sumitha, S. Vasanthi, S. Shalini, S. V. Chinni, S. C. B. Gopinath, P. Anbu, M. B. Bahari, R. Harish, S. Kathiresan and V. Ravichandran, Molecules, 2018, 23, 3311.

M.S.Alsalhi, S. Devanesan, A. A. Alfuraydi, R. Vishnubalaji, M. A. Munusamy, K. Murugan, M. Nicoletti and G. Benelli, Int. J. Nanomed., 2016, 11, 4439–4449.

M. K. Choudhary, J. Kataria, S. S. Cameotra and J. Singh, Appl. Nanosci., 2016, 6, 105– 111.

Z. H. Pak, H. Abbaspour, N. Karimi and A. Fattahi, Appl. Sci., 2016, 6, 69.

H. Padalia, P. Moteriya and S. Chanda, Arabian J. Chem., 2015, 8, 732–741.

M. Hariram, S. Vivekanandhan, V. Ganesan, S. Muthuramkumar, A. Rodriguez-uribe, A. K. Mohanty and M. Misra, Bioresour. Technol. Rep., 2019, 7, 100298.

B. Ajitha, Y. A. K. Reddy, Y. Lee, M. J. Kim and C. W. Ahn, Appl. Organomet. Chem., 2019, 33, e4867.

A. K. Mittal, D. Tripathy, A. Choudhary, P. K. Aili, A. Chatterjee, I. P. Singh and U. C. Banerjee, Mater. Sci. Eng., C, 2015, 53, 120–127.

S. Pugazhendhi, E. Kirubha, P. K. Palanisamy and R. Gopalakrishnan, Appl. Surf. Sci., 2015, 357, 1801–1808.

P. R. Rathi Sre, M. Reka, R. Poovazhagi, M. Arul Kumar and K. Murugesan, Spectrochim. Acta, Part A, 2015, 135, 1137 1144.

N. H. Rao, N. Lakshmidevi, S. V. N. Pammi, P. Kollu, S. Ganapaty and P. Lakshmi, Mater. Sci. Eng., C, 2016, 62, 553–557.

L. Pethakamsetty, K. Kothapenta, H. R. Nammi, L. K. Ruddaraju, P. Kollu, S. G. Yoon and S. V. N. Pammi, J. Environ. Sci., 2017, 55, 157–163.

K. M. Ezealisiji, X. S. Noundou and S. E. Ukwueze, Appl. Nanosci., 2017, 7, 905–911.

A. Sasikala, M. Linga Rao, N. Savithramma and T. N. V. K. V. Prasad, Appl. Nanosci., 2014, 5, 827–835.

D. Nayak, S. Ashe, P. R. Rauta, M. Kumari and B. Nayak, Mater. Sci. Eng., C, 2016, 58,44– 52.

S. Priya Velammal, T. A. Devi and T. P. Amaladhas, J. Nanostruct. Chem., 2016, 6, 247– 260.

S. Bhakya, S. Muthukrishnan, M. Sukumaran, M. Grijalva, L. Cumbal, J. F. Benjamin and M. V. Rao, RSC Adv., 2016, 6, 81436–81446.

Q. Ahmed, N. Gupta, A. Kumar and S. Nimesh, Artif. Cells, Nanomed., Biotechnol., 2016, 45, 1192–1200.

S. Pattanayak, M. Rahaman, D. Maity, S. Chakraborty, S. Kumar and S. Chattopadhyay, J. Saudi Chem. Soc., 2017, 21, 673–684.

G. Arya, R. M. Kumari, N. Gupta, A. Kumar and S. Nimesh, Artif. Cells, Nanomed., Biotechnol., 2017, 1–9.

S. Ramanathan, S. C. B. Gopinath, P. Anbu, T. Lakshmipriya, F. H. Kasim and C. G. Lee, J. Mol. Struct., 2018, 1160,80–91.