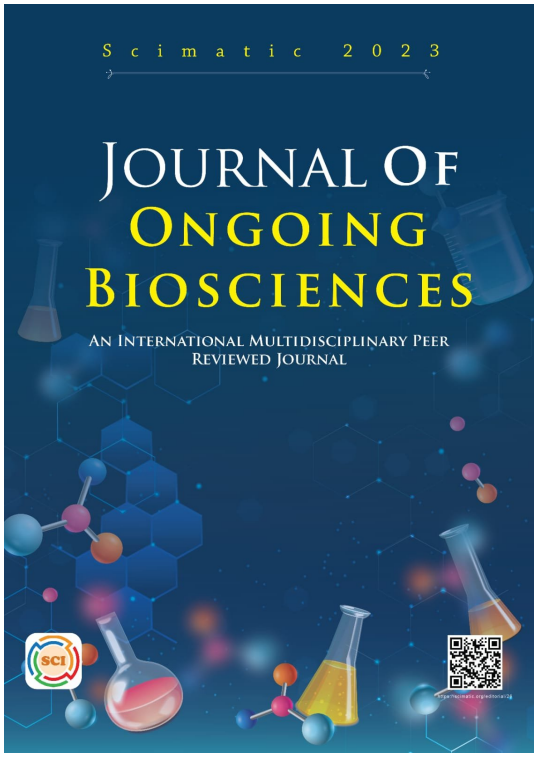
SILVER NANOPARTICLES: SYNTHESIS, APPLICATION HISTORY AND POSSIBLE TOXICITY IN BIOLOGICAL SYSTEM



JOURNAL OF ONGOING BIOSCIENCES

2023
Volume: 1
Issue: 1
Pages: 16-29
Document ID: 2023JOBS3
DOI:

J Ong Biosci, 2023, **1**(1): 16-29, Document ID: 2023JOBS3, doi:
Review

Silver Nanoparticles: Synthesis, Application History and Possible Toxicity in Biological System

Raza Ullah*, Salman Khan, Shaghfar Ali Malik, Mudassar Shah, Amir Khan, Muhammad Sohail
For affiliations and correspondence, see the last page.

Abstract

Silver nanoparticles (AgNPs) have been extensively studied by researchers due to their unique properties such as size, shape, optical, antimicrobial and electrical properties. A variety of preparation methods have been reported for the synthesis of silver nanoparticles, including laser ablation, gamma irradiation, chemical reduction, electron irradiation, microwave processing, photosynthetic methods and biological synthetic methods. AgNPs have widespread application in wastewater treatment, disease treatment, animal husbandry, fisheries and as antibacterial and antifungal agents but the toxicity of chemically synthesized AgNPs in biological system remains the concern which depends on the morphology of AgNPs. This review provides a comprehensive insight to the various techniques notably, physical, chemical and biological methods used to synthesize silver NPs. The aim of this review article is therefore to reflect the benefits of the biological techniques used for the synthesis of silver NPs and also describes some fundamental issues about non-biological techniques.

Keywords: Toxicity, Silver Nanoparticles, Chemical Synthesis, Biological Synthesis, Nanoparticle Synthesis, Physical Synthesis

Nanotechnology is a branch of science, which deals the matter at Nano scale. It is a rapidly growing technology and has gained interest in the last decade due to the history of its wide applications. It is a multi-disciplinary field and was first revealed by Richard Feynman in 1959 [1]. In 1974 Norio Tanaguchi defined nanotechnology as "being able to manipulate a single nanoscale object" [2]. "Nano" is a word, which means one-billionth of physical unit (I-e 1nm). Till now there is no agreement on the definition of nanotechnology [3]. A nanometer (nm) is a unit of measurement that is equal to one billionth of a meter. Therefore, nanotechnology deals with the study of nanomaterials, which have a size between 1 to 100 nm [4]. Nanotechnology may be defined as "the synthesis and application of materials by scientific knowledge to manipulate in the nanoscale (1-100 nm)" [1], by the United States National Nanotechnology Initiative [5]. However, some slight changes are existing in this definition such as the International Organization for Standardization (ISO), has claimed that the nanomaterials can also be found in large size and sometimes maybe 1000 nm [6]. The unique initial chemical, biological, and physical properties of nanoparticles enable them to act as a suitable agent to perform many functions at the cellular and subcellular levels [7]. Paul Ehlirch, for the first time, introduced the concept of targeted therapy or so-called "magic bullets" which means to intended cellular level target with damaging healthy cells [5]. The idea of "magic bullets" was further fused into the concept of nanoparticles [8].

Nanoparticles (NPs) are said to be raw materials used in nanotechnology [9]. These raw materials (NPs) are found in different types e.g. gold, copper, iron, nickel, and silver nanoparticles (AgNPs) [10]. In the past, gold was only known as metal, but later on, with the advancement of nanotechnology, it was realized that the physiochemical properties of gold could make it an ideal material for the synthesis of gold nanoparticles [11]. Gold nanoparticles have gained an attraction due to their chemical and biological properties [12]. Nickel and copper have been investigated for different applications [9]. However, concerns have been stated that nickel nanoparticles might play a key role in biological activities [13]. Iron nanoparticles (FeNPs) are a class of nanomaterials that are being broadly used in the therapeutic and environmental applications (Beheshtkhoo et al., 2018), while silver is a transition, lustrous, and white element in the periodic table, that has been extensively known for therapeutically, environmental, and medical benefits [16]. Medically, silver has been using for over 2000 years and silver-

based compounds have been used as antibacterial since the 19th century [17]. The uniqueness of AgNPs is that it has been explored in different areas of human life e.g. washing machines, food, medicine, and fabrics on a large scale (McGillicuddy et al., 2017).

Nanotechnology is one of the most progressive field in many industrial areas at the atomic and molecular levels. The resulting materials have probably novel characteristics regarding their function with small size. [20]. Nanoscience is being developed as a multidisciplinary field based on the key properties of Nano-size materials [21]. NPs recollect amazing marantic, optical, catalytic, biological, and electronic properties, and these properties are because of their higher surface area to the volume ratio [22]. There are certain kinds of nanoparticles but the AgNPs have gained more attention due to of their chemical, biological and physical properties [23]. The size of chemical synthesized AgNPs was 10-100 nm, which defines its good activity to remove certain kinds of micro-fauna [24]. For these biological activities, nanomaterials can be existed as nanotubes, nanorods, dendrimers, fullerenes, nanowires, quantum dots, and nanoparticles [25].

Acknowledgements

We thank Mr. Raza Ullah for his effortless contribution and guidance through out the journey to complete, analyze and publish this work

Bibliography

1. Calipinar, H., & Ulas, D. (2019). Development of Nanotechnology in the World and Nanotechnology Standards in Turkey. *Procedia Computer Science*, *158*, 1011–1018. https://doi.org/https://doi.org/10.1016/j.procs.2019.09.142
2. Mulvaney, P. (2015). Nanoscience vs Nanotechnology Defining the Field. ACS Publications.
3. Satalkar, P., Elger, B. S., & Shaw, D. M. (2016). Defining nano, nanotechnology and nanomedicine: why should it matter? *Science and engineering ethics*, *22*(5), 1255–1276.
4. He, X., Deng, H., & Hwang, H. (2019). The current application of nanotechnology in food and agriculture. *Journal of food and drug analysis*, *27*(1), 1–21.
5. Leon, L., Chung, E. J., & Rinaldi, C. (2020). Chapter 1 - A brief history of nanotechnology and introduction to nanoparticles for biomedical applications. In E. J. Chung, L. Leon, & C. B. T.-N. for B. A. Rinaldi (Eds.), *Micro and Nano Technologies* (pp. 1–4). Elsevier. https://doi.org/https://doi.org/10.1016/B978-0-12-816662-8.00001-1
6. Gubala, V., Johnston, L. J., Liu, Z., Krug, H., Moore, C. J., Ober, C. K., … Vert, M. (2018). Engineered nanomaterials and human health: Part 1. Preparation, functionalization and characterization (IUPAC Technical Report). *Pure and Applied Chemistry*, *90*(8), 1283–1324.
7. Viswanathan, V. K., Rajaram Manoharan, S. R., Subramanian, S., & Moon, A. (2019). Nanotechnology in Spine Surgery: A Current Update and Critical Review of the Literature. *World Neurosurgery*, *123*, 142–155. https://doi.org/https://doi.org/10.1016/j.wneu.2018.11.035
8. Kreuter, J. (2007). Nanoparticles—a historical perspective. *International journal of pharmaceutics*, *331*(1), 1–10.
9. Magaye, R., & Zhao, J. (2012). Recent progress in studies of metallic nickel and nickel-based nanoparticles' genotoxicity and carcinogenicity. *Environmental Toxicology and Pharmacology*, *34*(3), 644–650. https://doi.org/https://doi.org/10.1016/j.etap.2012.08.012
10. Geng, Y., Khodadadi, H., Karimipour, A., Reza Safaei, M., & Nguyen, T. K. (2020). A comprehensive presentation on nanoparticles electrical conductivity of nanofluids: Statistical study concerned effects of temperature, nanoparticles type and solid volume concentration. *Physica A: Statistical Mechanics and its Applications*, *542*, 123432. https://doi.org/https://doi.org/10.1016/j.physa.2019.123432
11. Kalimuthu, K., Cha, B. S., Kim, S., & Park, K. S. (2020). Eco-friendly synthesis and biomedical applications of gold nanoparticles: A review. *Microchemical Journal*, *152*, 104296. https://doi.org/https://doi.org/10.1016/j.microc.2019.104296
12. Salata, O. V. (2004). Applications of nanoparticles in biology and medicine. *Journal of nanobiotechnology*, *2*(1), 3.
13. Maynard, A. D., & Kuempel, E. D. (2005). Airborne nanostructured particles and occupational health. *Journal of nanoparticle research*, *7*(6), 587–614.
14. Muthukumar, H., & Matheswaran, M. (2015). Amaranthus spinosus leaf extract mediated FeO nanoparticles: physicochemical traits, photocatalytic and antioxidant activity. *ACS Sustainable Chemistry & Engineering*, *3*(12), 3149–3156.
15. Beheshtkhoo, N., Kouhbanani, M. A. J., Savardashtaki, A., Amani, A. M., & Taghizadeh, S. (2018). Green synthesis of iron oxide nanoparticles by aqueous leaf extract of Daphne mezereum as a novel dye removing material. *Applied Physics A*, *124*(5), 363.
16. Beyene, H. D., Werkneh, A. A., Bezabh, H. K., & Ambaye, T. G. (2017). Synthesis paradigm and applications of silver nanoparticles (AgNPs), a review. *Sustainable Materials and Technologies*, *13*, 18–23. https://doi.org/https://doi.org/10.1016/j.susmat.2017.08.001
17. Hussein, S. (2014). Phytosynthesis of nanoparticles: concept, controversy and application, Nanoscale Res. *Lett*, *9*, 229.
18. Zhang, X.-F., Liu, Z.-G., Shen, W., & Gurunathan, S. (2016). Silver nanoparticles: synthesis, characterization, properties, applications, and therapeutic approaches. *International journal of molecular sciences*, *17*(9), 1534.
19. McGillicuddy, E., Murray, I., Kavanagh, S., Morrison, L., Fogarty, A., Cormican, M., … Morris, D. (2017). Silver nanoparticles in the environment: Sources, detection and ecotoxicology. *Science of the Total Environment*, *575*, 231–246.
20. Meyer, M., & Kuusi, O. (2006). Nanotechnology: generalizations in an interdisciplinary field of science and technology. In *Nanotechnology Challenges: Implications for Philosophy, Ethics and Society* (pp. 181–199). World Scientific.
21. Mohanpuria, P., Rana, N. K., & Yadav, S. K. (2008). Biosynthesis of nanoparticles: technological concepts and

future applications. *Journal of nanoparticle research*, *10*(3), 507–517.

22. Poulose, S., Panda, T., Nair, P. P., & Theodore, T. (2014). Biosynthesis of silver nanoparticles. *Journal of nanoscience and nanotechnology*, *14*(2), 2038–2049.
23. Fayaz, A. M., Balaji, K., Girilal, M., Yadav, R., Kalaichelvan, P. T., & Venketesan, R. (2010). Biogenic synthesis of silver nanoparticles and their synergistic effect with antibiotics: a study against gram-positive and gram-negative bacteria. *Nanomedicine: Nanotechnology, Biology and Medicine*, *6*(1), 103–109.
24. Chávez, M. C. G., González, R. C., & Hernández, J. C. M. (2013). Nanopartículas para el control del biodeterioro en monumentos históricos. *Mundo Nano. Revista Interdisciplinaria en Nanociencias y Nanotecnología*, *6*(10).
25. Cui, Y., Wei, Q., Park, H., & Lieber, C. M. (2001). Nanowire nanosensors for highly sensitive and selective detection of biological and chemical species. *science*, *293*(5533), 1289–1292.

Affiliations and Corresponding Informations

Corresponding: Raza Ullah
Email: razanisar51@gmail.com
Phone: 008618419164380

Raza Ullah:
2State Key Laboratory of Grassland Agro-ecosystem, School of Life Sciences, Lanzhou University, Lanzhou 730000, Gansu Province, China

Salman Khan:
1College of Biological and Pharmaceutical Sciences, China Three Gorges University, Yichang, China

Shaghfar Ali Malik:
School of Physical Science and Technology, Lanzhou University, Lanzhou 730000, China

Mudassar Shah:
4State Key Laboratory of Grassland Agro-ecosystem, International Centre for Tibetan Plateau, Ecosystem Management, School of Life Sciences, Lanzhou University, Lanzhou 730000, China

Amir Khan:
6Ministry of Education Key Laboratory of Cell Activities and Stress Adaptation, School of Life Sciences, Lanzhou University 730000, Lanzhou, China

Muhammad Sohail:
4State Key Laboratory of Grassland Agro-ecosystem, International Centre for Tibetan Plateau, Ecosystem Management, School of Life Sciences, Lanzhou University, Lanzhou 730000, China