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Nanotechnology, Synthesis and Theoretical Investigation of Antimicrobial and Anticancer Effects of Silver Nanoparticles in Faster Diagnosis and Treatment of Various Cancers: A Review

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ABSTRACT

The use of silver nanoparticles as a safe and effective cancer treatment is a challenging endeavor that calls for intricate research including biologists who can assess how these relatively novel systems affect human cells as well as physicists, chemists and engineers who build and manufacture nanoparticles. In terms of cytotoxicity and the capacity to harm cancerous cells, they are in touch with them. Future applications of silver in nanomedicine include antibacterial therapies, medication delivery, biosensor systems, medical and cellular imaging methods and anti-cancer therapy. Silver nanoparticles have the potential to be quite helpful in delivering anticancer medications and resolving some of the issues with traditional therapies. Silver nanoparticles can work in concert with anticancer medications and enable the use of lower dosages, according to analyses. As a result, these nanocarriers are less harmful to cells. It is anticipated that this field of study will grow in the upcoming years with a wider range of anticancer medications and further understanding of the behavior of nanosystems in vivo with regard to absorption, distribution, metabolism and excretion And Lastly, silver nanoparticles (AgNPs) have been established as a superior antibacterial agent to combat infection-causing bacteria both in vivo and in vitro. Both gram-positive and gram-negative bacteria, including those that are resistant to several drugs, are susceptible to the antibacterial properties of silver nanoparticles. Because of their characteristics, silver nanoparticles can be used in health and medical goods to cure or prevent infections.

Key words: Antibacterial, Antimicrobial agent, Cancer treatment, Nanomedicine, Silver nanoparticles.

Nanomaterials-engineered particles typically 1-100 nanometers in size-have emerged as powerful tools in oncology. Their unique properties (*e.g.*, high surface area, silver nanoparticles make up 65% of all nanoparticles worldwide, tunable size, controlled release and functionalization potential) allow them to improve diagnosis, targeted drug delivery, imaging and therapy.

Key roles of nanomaterials in cancer treatment include: Targeted Drug Delivery, Nanocarriers (liposomes, polymeric nanoparticles, dendrimers, gold nanoparticles) can selectively deliver chemotherapeutic agents to tumors, minimizing systemic toxicity.

Theranostics (Therapy + Diagnostics). Nanoparticles can combine therapeutic and imaging functions, enabling simultaneous tumor localization and treatment (Li *et al.,* 2024; Ahmad *et al.*, 2024). Numerous substances found in food, water and the air, as well as prolonged exposure to sunlight, can cause cancer. Alcohol, tobacco, food, obesity, lack of physical exercise, chronic illnesses and occupational and environmental risks are risk factors for cancer (Siegel *et al.*, 2025; Lee *et al.*, 2013).

There were 4/7 million recorded deaths from various forms of cancer in 2004 (Siegel *et al.*, 2022; Nedelcu *et al.*, 2014). The World Health Organization states that one of the main causes of mortality globally is cancer. About 14 million new cases and 2/8 million cancer-related deaths were recorded in 2012 (Vikesland *et al.*, 2012).

Due to environmental risk factors and a poor prognosis, over 70% of cancer fatalities currently take place in low- and middle-income nations. According to Fig 1-1, lung cancer accounts for 8 out of every million cases, or 13% of all cancer diagnoses. colorectal (4/1 million, 7/9%); and breast (7/1 million, 11.9%) (Abbasi *et al.*, 2014; Hasan *et al.*, 2024).

The following categories were linked to the most frequent causes of cancer-related deaths: Lung (4/19% of the total, 6/1 million). stomach (7/0 million, 8/8%) and liver (8/0 million, 1/9%).

Silver nanoparticles

Because of their numerous uses, silver nanoparticles have a variety of desired features that vary depending on their size and form. These properties include optical, chemical, magnetic and physical characteristics. Biosensors, composite fibers, antimicrobial materials, cosmetics and hygiene goods and electrical compositions are just a few of the numerous items that might include them. Additionally,

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silver nanoparticles can be employed in cellular electrodes, medication administration, filters, medical imaging and nanocomposites. Because silver absorbs light better than other nanoparticles, it has a higher propensity to become active and improves clarity. Because silver nanoparticles have antibacterial properties against bacteria, fungus and viruses, they are presently utilized in medicine (Tran *et al*., 2013; Iravani *et al*., 2014).

Synthesis

Chemical or physical processes include cell process, chemical precipitation, pyrolysis, hydrothermal technique and chemical vapor deposition are used to create nanomaterials. Although many of these techniques are straightforward, they compromise the stability of the output. Recently, green chemistry-an ecologically benign technique was used to create nanoparticles. Every technique has benefits and drawbacks, but the main issues are high expense, particle size and particle dispersion (Kalishwaralal *et al.,* 2008).

Chemical synthesis

The most popular technique currently in use for creating silver nanoparticles in liquids is chemical synthesis. The process uses organic or mineral reducing agents to chemically regenerate. Many substances, including sodium citrate, ascorbate, toluene, polyal process, N-dimethyl formamide, block polymers (ethylene glycol), *etc*., can renew silver ions (Ag1) in aqueous or non-aqueous solutions. Metallic silver, which is produced via aggregating into oligometric clusters and eventually metallic colloidal silver particles, is the result of these processes. When creating silver nanoparticles, stabilizing and protecting them requires the employment of protective chemicals to stop aggregation (Vigneshwaran *et al*., 2007; Ingle *et al*., 2008).

Physical synthesis

Evaporative condensation and laser erosion are the two physical synthesis methods most frequently employed to produce metal nanoparticles. A tube furnace and atmospheric pressure are necessary for a physical approach. The homogeneity of the nanoparticle dispersion and the lack of solvent contamination are the benefits of a physical approach over a chemical one. The huge size of the tube furnace, the high energy consumption and the lengthy time required to establish thermal stability (it takes many tens of minutes to attain a steady working temperature) are the drawbacks of physical synthesis. The temperature differential between the area around the heater surface and the tube furnace causes the evaporated vapors to cool, forming tiny nanoparticles (George *et al*., 2016; Gali-Muhtasib *et al*., 2020).

Biological synthesis

Numerous research demonstrate that green chemistry may be used to create silver nanoparticles of various sizes and shapes. As previously stated, three ingredients are needed to create silver nanoparticles: stabilizer, reducing agent and silver salt. The use of hazardous and costly chemicals is avoided in biological synthesis by substituting molecules of living things, such as enzymes, proteins, amino acids, polysaccharides and vitamins, for the reducing agent. Numerous microorganisms, including bacteria, fungus, algae and plants, may produce them. Cost-effectiveness, reproducibility and a reduced energy need than alternative techniques are some further benefits (Ealia *et al*., 2017; Lara *et al*., 2010).

Silver nanoparticles – Applications for cancer diagnosis and treatment

Leukemia

A class of malignancies known as leukemia often begins in the bone marrow and produces a significant number of hygiene goods and electrical compositions are just a few of the numerous items that might include them. Additionally, silver nanoparticles can be employed in cellular electrodes, medication administration, filters, medical imaging and nanocomposites. Because silver absorbs light better than other nanoparticles, it has a higher propensity to become active and improves clarity. Because silver nanoparticles have antibacterial properties against bacteria, fungus and viruses, they are presently utilized in medicine. (Tran *et al*., 2013; Iravani *et al*., 2014).

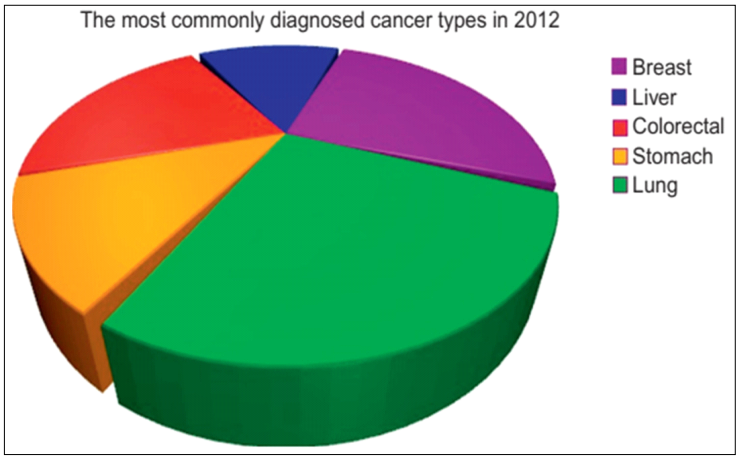


Fig 1: The world health organization published statistics on the number of cancer cases diagnosed in 2012 on December 12, 2013.

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Silver nanoparticles - Applications for cancer diagnosis and treatment

Leukemia

A class of malignancies known as leukemia often begins in the bone marrow and produces a significant number of solution containing silver nitrate, then magnetically swirling the mixture until a pale yellow hue was achieved in order to create silver nanoparticles. PVP was employed as a capping agent to make AgNPs more stable and stop them from aggregating (Hasan *et al.*, 2024).

The anticancer drug imatinib

The anticancer medication imatinib is used to treat a variety of solid tumors, including skin and stomach cancer, as well as some forms of leukemia. It does, however, carry a significant risk of adverse consequences, such as coughing,

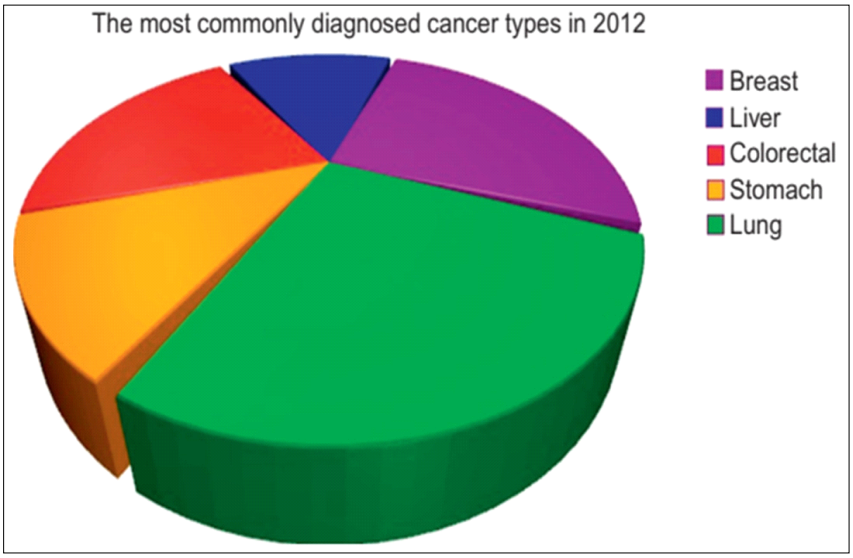


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breathing difficulties, muscular soreness, exhaustion and bleeding. In 2017, Shandiz created silver nanoparticles coupled with imatinib (IMAB) by biosynthesis (Hasan *et al.*, 2024).

Antibacterial effect of silver nanoparticles

Several Gram-positive and Gram-negative bacteria have been shown to be effectively inhibited by AgNPs. Nevertheless, it is still unclear exactly how they produce their bactericidal or growth-inhibiting effects. Numerous processes that consider the physical characteristics of AgNPs, such as their size and surface area, which enable them to interact or even pass through cell walls or membranes and directly impact intracellular components, are supported by the current experimental data (Al-Hakeim *et al.*, 2016).

Mechanisms of antibacterial effect

There are now three main pathways that AgNPs use to achieve their antibacterial activity, either in combination or independently, according to the research. According to the first theory, silver nanoparticles act at the membrane surface because they can pass through the outer membrane and gather in the inner membrane. Once there, their adherence to the cell destabilizes and damages the nanoparticles, increasing membrane permeability and allowing cell contents to leak out. and then its demise. Additionally, it has been demonstrated that silver nanoparticles can interact with bacterial cell wall proteins that contain sulfur, potentially causing structural damage that results in cell wall rupture (Ali *et al.*, 2024).

Factors affecting the antibacterial activity of silver nanoparticles

The mechanisms behind AgNPs' antibacterial activity have been clarified and the effects of the nanoparticles' surface, charge and chemical size on their antibacterial activity have also been ascertained (Mashlawi *et al.*, 2024).

AgNPs as an alternative to combat human pathogenic bacteria

AgNPs have emerged as a viable substitute in the fight against a variety of microbes. AgNPs have special properties that make them effective against bacteria that are resistant to drugs, in addition to their capacity to stop the growth of these strains.Initially, it has been demonstrated that silver is the most potent metal nanoparticle against bacteria and other pathogens, as well as bio It is well renowned for its extremely high compatibility and ease of use in medical applications (El-Naggar *et al.,* 2023).

In vitro toxicity measurement after exposure to silver nanoparticles

Since the creation of new AgNP-based goods and technologies has progressed so quickly, a large number of studies have been conducted to determine the possible harmful consequences of high AgNP exposure. Given that using medicinal goods containing AgNPs may result in ingestion, inhalation, or exposure to these particles, this section reviews the *in vitro* effects of various dosages and sizes of AgNPs in mammalian cells to provide background information on these consequences. This nanomaterial covers the skin (Tamara Bruna *et al.,* 2021).

Antiviral properties of silver nanoparticles

Numerous viruses, including the human immunodeficiency virus (HIV), herpes simplex virus (HSV), influenza and hepatitis, can be fatal. Medicine has not yet created a broad-spectrum antiviral vaccination, despite the fact that several vaccines have been created to combat different viruses. Additionally, these viruses are becoming resistant to traditional antiviral medications and current therapies, particularly in individuals with impaired immune systems (Gali-Muhtasib *et al.*, 2020).

Recent statistics on cancer patients

Nearly 20 million new cancer cases and 9.7 million cancer deaths occurred worldwide.
Top global cancers in incidence:
Lung (≈2.5/ M cases, 12.4%)
Breast (≈2.3/ M, 11.6%)
Colorectal (≈1.9/ M, 9.6%)
Leading cancer deaths:
Lung (~1.8/ M, 18.7%) ,Colorectal (~0.9/ M), liver (~0.76/ M), breast (~0.67/ M) and stomach (~0.66/ M) [40,41].

CONCLUSION

The application of silver nanoparticles as a safe and efficient cancer treatment is a challenging endeavor that calls for intricate research integrating biologists who can assess the effects of these relatively novel systems on cells as well as physicists, chemists and engineers who design and create nanoparticles. Their cytotoxicity and capacity to harm cancerous cells are in touch with them.

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Declaration of conflicting interests

The writers affirm that there are no potential conflicts of interest between them.

REFERENCES

Abbasi, E., Milani, M., Aval, S.F., Kouhi, M., Akbarzade, A., Nasrabadi, H.T., *et al.* (2014). Silver nanoparticles: Synthesis methods, bio-applications and properties. *Crit. Rev. Microbiol.* **17:** 18.

Agnihotri, S., Mukherji, S., Mukherji, S. (2014). Size-controlled silver nanoparticles synthesized over the range 5-100 nm using the same protocol and their antibacterial efficacy. *RSC Adv*. **4:** 3974-3983.

Ali, I.Q. (2024). Evaluation of microRNA-9 expression levels in Iraqi women patients with breast cancer. *Journal of Bioscience and Applied Research*. **10(3):** 421-426.

Ahmad, A., Haneef, M., Ahmad, N., Kamal, A., Jaswani, S. and Khan, F. (2024). Biological synthesis of silver nanoparticles and their medical applications. *World Academy of Sciences Journal*. **6(3):** 22.

Al-Hakeim, H.K., Al-Ankoshy, A.M. and Alsharifi, M.R. (2016). Efficiency of Fetuin-A and procalcitonin in the diagnosis of infection in patients with febrile seizure. *Acta Facultatis Medicae Naissensis*. **33(1):** 31.

Alsadee, S.A., Mohammed, S.A. and Hasan, A.F. (2024). Hepatotoxicity of oral sub-chronic exposure to thiamethoxam and lambda cyhalothrin in rats. *Agricultural Reviews*. **45(4):** 728-733. doi: 10.18805/ag.RF-350.

Alyasiri, T., Hameed, H. M. and Hasan, A.F. (2025). The effects of bisphenol a of polycarbonate plastics on various blood and fertility parameters, along with histological changes in male albino rats. *Asian Journal of Dairy and Food Research*. **44(2):** 313-319. doi: 10.18805/ajdfr.DRF-435.

Ealia, A.M., Saravanakumar, M.P. (2017). A review on the classification, characterisation, synthesis of nanoparticles and their application. *IOP Conf. Ser. Mater. Sci. Eng.* **263:** 032019.

El-Naggar, S.A., Basyony, M.A., El-Feki, S.M. and Kandyel, R.M. (2023). Parotoid gland secretions of the Egyptian toad (*Bufo relgularis*): *In vivo* antitumor effect on Ehrlich ascites carcinoma bearing mice. *Journal of Bioscience and Applied Research*. **9(1):** 33-45.

Ezz, A.M., Zaki, S. and Tabl, G.A. (2023). Anti-diabetic effects of pomegranate peel extract and L-carnitine on streptozotocin induced diabetes in rats. *Biomedical and Pharmacology Journal*. **16(3):** 1827-1835.

Gali-Muhtasib, H. and Chouaib, R. (2020). Nanoparticles in cancer treatment: Types and preparation methods. In Nanoparticle Drug Delivery Systems for Cancer Treatment, 1st ed.; Jenny Stanford Publishing: Boca Raton, FL, USA.

George¸ M.V., Stefania, M., Roxana, E.,Tiplea, Ioana, R.B., Mad ¢ A.L. and Maria, M.M. (2016). Alexandru Mihai Grumezescu and Ecaterina Andronescu, Nanobiomaterials in Cancer Therapy, 2016 Elsevier.

Hameed, H.M., Razooki, Z.H., Hasan, A.F., Rasool, A.A.A.A. and Abed, I.J. (2025). Therapeutic effect of essential oils (*Citrus sinensis*) against ehrlich ascites model induced renal toxicity in female mice. *Agricultural Science Digest*. **45(2):** 317-322. doi: 10.18805/ag.DF-632.

Hasan, A.F., Hameed, H.M., Hadid, M.A. and Tousson, E. (2024). Impact of chia (*Salvia hispanica*) seeds extract on ehrlich ascites model induced kidney toxicity in female mice. *Asian Journal of Dairy and Food Research*. **43(4):** 750-756. doi: 10.18805/ajdfr.DRF-397.

Hasan, A.F., Jasim, N.A., Abid, A.T. and Tousson, E. (2024). Role of Salvia hispanica seeds extract on ehrlich ascites model induced liver damage in female mice. *Journal of Bioscience and Applied Research*. **10(2):** 161-169.

Hassan, A.A., Adil, H., Alyasiri, T., Alsayed, R., Makia, R., Kadhom, M. and Yousif, E. (2024). Nickel oxide nanoparticles with ginger extract: An environmentally sustainable method for antibacterial applications. *Results in Chemistry*. **9:** 101617.

Helena, I.O. Gomes, Catarina, S.M. Martins and João, A.V. (2021). Prior, silver nanoparticles as carriers of anticancer drugs for efficient target treatment of cancer cells. *Nanomaterials*. **11:** 964.

Ingle, A., Gade, A., Pierrat, S., So¨nnichsen, C. and Mahendra, R. (2008). Mycosynthesis of silver nanoparticles using the fungus fusarium acuminatum and its activity against some human pathogenic bacteria. *Curr. Nanosci*. **4:** 141144.

Iravani, S., Korbekandi, H., Mirmohammadi, S.V. and Zolfaghari, B. (2014). Synthesis of silvernanoparticles: Chemical, physical and biological methods. *Res. Pharm. Sci.* **9:** 385406.

Kalishwaralal, K., Deepak, V., Ramkumarpandian, S., Nellaiah, H. and Sangiliyandi, G. (2008). Extracellular biosynthesis of silver nanoparticles by the culture supernatant of Bacillus licheniformis. *Mater. Lett*. **62:** 44114413.

Lara, H.H., Ayala-Núñez, N.V., Turrent, L.D.C.I. and Padilla, C.R. (2010). Bactericidal effect of silver nanoparticles against multidrug-resistant bacteria. *World J. Microb. Biot*. **26:** 615-621.

Lee, B.K., Yun, Y.H. and Park, K. (2013). Introduction to Biomaterials for Cancer Therapeutics. Woodhead Publishing Limited, Lafayette, Indiana, USA.

Li, G., Wang, C., Jin, B., Sun, T., Sun, K., Wang, S. and Fan, Z. (2024). Advances in smart nanotechnology-supported photodynamic therapy for cancer. *Cell Death Discovery*. **10(1):** 466.

Marambio-Jones, C. and Hoek, E.M.V. (2010). A review of the antibacterial effects of silver nanomaterials and potential implications for human health and the environment. *J. Nanopart. Res*. **12:** 1531-1551.

Mashlawi, A.M., Alanazi, N.A.H., Mohamed, G., Alfattah, M.A., Mohamed, D.A., Fayad, E. and Salama, S. A. (2024). Exploring the phytochemical composition of methanolic extract from launaea nudicaulis: Investigating its antioxidant, anticancer and anti-dengue activities against aedes aegypti. *Journal of Bioscience and Applied Research*. **10(1):** 30-41.

Nedelcu, I.A., Ficai, A., Sonmez, M., Ficai, D., Oprea, O. and Andronescu, E. (2014). Silver based materials for biomedical application. *Curr. Org. Chem*. **18:** 173184.

Siegel, R.L., Kratzer, T. B., Giaquinto, A.N., Sung, H. and Jemal, A. (2025). Cancer statistics. *Ca*. **75(1):** 10-45.

Siegel, R.L., Miller, K. D., Fuchs, H. E. and Jemal, A. (2022). Cancer statistics. CA: *A Cancer Journal for Clinicians*. **72(1).** doi:10.3322/caac.21708.

Silva, L.P., Silveira, A.P., Bonatto, C.C., Reis, I.G. and Milreu, P.V. (2017). Silver nanoparticles as antimicrobial agents: Past, present and future in nanostructures for antimicrobial therapy: Nanostructures in therapeutic medicine series; elsevier: Amsterdam, The Netherlands, pp. 577-596, ISBN 9780 323461511.

Tamara Bruna, Francisca Maldonado-Bravo, Paul Jara and Nelson Caro, (2021). Silver nanoparticles and their antibacterial applications. *Int. J. Mol. Sci.* **22:** 7202.

Tran, Q.H., Nguyen, V.Q. andLe, A.T. (2013). Silver nanoparticles: Synthesis, properties, toxicology, applications and perspectives. Adv. Nat. Sci. Nanosci. Nanotechnol. 4, Article ID 033001.

Vigneshwaran, N., Ashtaputre, N.M., Varadarajan, P.V., Nachane, R.P., Paralikar, K.M. and Balasubramanya, R. (2007). Biological synthesis of silver nanoparticles using the fungus *Aspergillus flavus*. *Mater. Lett*. **61:** 14131418.

Vikesland, P.J., Dietrich, A.M. and Marr, L.C. (2012). Controlled evaluation of silver nanoparticle dissolution using atomic force microscopy. Blacksburg, VA. *Environ. Sci. Technol*. **46:** 69776984.