METHODS FOR MANUFACTURING OF GOLD NANOPARTICLES AND THEIR APPLUCATIONS

Yasmeen JUNEJO

Muhammad SAFDAR

Mehmet ÖZASLAN

1. Synthesis of Gold Nanoparticles

Gold nanoparticles (AuNPs) were synthesized in 1951 had seen the development of a synthetic procedure for producing AuNPs, using the boiling water treatment of hydrogen tetrachloroaurate (HAuCl4) with citric acid, where the citrate serves as a reducing and stabilizing agent (Turkevich, Stevenson, & Hillier, 1951). The size, shape, and surface functionality of these nanoparticles was controlled using a variety of solution-based techniques that have been developed in recent years (Bayda, Adeel, Tuccinardi, Cordani, & Rizzolio, 2019; Safdar & Özaslan, 2022).

2. Methods of Gold Nanoparticle Synthesis

Many methods of gold nanoparticles are available these days such as, physical, chemical and biological methods which are according to the interactions of numerous natural as well as synthetic compound methods and these are included with many chemical branches (Patra et al., 2018).

3. Biological Synthesis

Several ways are available for biological and chemical synthesis of nanoparticles, which are corresponding to new synthesis of gold nanoparticles via *Jatropha curcas* leaf extract. Some authors represented synthesis of AuNPs utilizing jackfruit tree L. seed extract (Khadka et al., 2018). The scientists showed a way for AuNPs preparation with green and non-toxic way with the help of leaf extract which can be used as stabling agents.

In another report, AuNPs were green when they were prepared with the help of leaf extract of *Azadirachta indica* and *Triphala* as it was used as a flavoring mixture (Kora & Rastogi, 2013). They synthesized smaller size NPs as they contained the antioxidant factors. Some researchers used *staphylococci aureus* for the treatment of AuNPs and has been monitored via UV Visible for the formation of new materials (Kumar et al., 2018). In another report *Aspergillus flavus* has been used to synthesis of AuNPs for the treatment of plants diseases and the size of NPs was about 8 nm (Li, Zhao, & Astruc, 2014) of the NPs was established with the help diffraction spectrum and FT-IR spectrographic analysis displayed supply of super molecule for synthesis of AuNPs (Logeswari, Silambarasan, & Abraham, 2015). The exploitation of plant life to synthesize AuNPs provides eco-friendly environment for the production of health and use of technique for pilot scale (Maráková et al., 2017).

4. Chemical Synthesis

The AuNPs can be fabricated by different methods. Every technique includes each blessing and drawbacks with common issues concerning shapes, size distribution and particle sizes. Despite the higher than mentioned ones, several chemical ways are delineated for production of AuNPs (Michailidis et al., 2017). Compared to others, chemical ways supply relatively easier to synthesize Au-NPs in resolution. Primarily, the reduction of many compounds or salts has Au+ ions forms gold atoms Au (0), leading to cluster formation (Minhas et al., 2018). These clusters ultimately form mixture of nanoparticles. With such metal salts employing a reductant adore borohydride, a really little particles, it absolutely was troublesome to manage the assembly of larger particles. In distinction, a change state has terribly weak reduction, however the dimensions distribution is slightly larger that comparatively show the good quantitative relation (Niedermeyer, 2018).

5. Photochemical Synthesis

The photo-induced artificial methods are classified into two various approaches. These should be divided into topdown and bottom up, that square measure the photo-physical (top down) and photo-chemical (bottom up) ones. The photo-physical might prepare the NPs via the subdivision of bulk metals and therefore the chemistry synthesis the NPs were generates from the ionic precursors (metal salts). The square nanoparticles measure were made by the reduction of metal salts directly by different physical and chemical methods as photos (Safdar, Junejo, & Balouch, 2015). We knows some direct photo-reduction methods for the salt of $HAuCl_4$ in presence of Na turn was through varied lightweight sources of different metals such as cyan, UV, blue, white, inexperienced and orange at temperature (Vijayakumar, Priya, Nancy, Noorlidah, & Ahmed, 2013). These variations were involving the dimensions and form of particles having totally different optical properties (Vijayan, Joseph, & Mathew, 2018).

6. Applications of Gold Nanoparticles

Further distinctive properties of gold nanoparticles comprise their utilization in light and surface plasmon resonance (SPR). To Illustrate, SPR happens upon irradiating gold nanoparticles with actinic radiation, that was then causes the oscillation of free electrons within the physical phenomenon band of nanoparticles. The position and breadth of SPR peak depends upon the particle form and size (Yallappa et al., 2017). These properties allow gold nanoparticles to be employed in sensing applications like optical device desorption/ionization mass qualitative analysis of peptides, quantitative analysis detector for essential amino acid, determination of fibrinogens in human plasma, detection of deoxyribonucleic acid sequences, colorimetric sensors for measure ammonia concentration, period searching of membrane transport in living microorganism cells, biolabeling, optical imaging of cancer, biosensors for detection of herbicides, increased IR absorption spectrographic analysis, and aldohexose detector for medical nosology (Zada et al., 2018). SERS analysis techniques will be used to observe trace analysis of anthrax, nuclear waste, pesticides, genetic nosology, prostate-specific matter aldohexose, identification of microorganism, detection of nitro-explosives, and immunochemical assay labeling (Zheng, Sip, Leong, & Huo, 2018).

7. Antibacterial Applications

Many researchers speculated about the potential medical benefits of ,AuNPs such as antibiotic based gold nanoparticles or composite of these nanoparticles, but unfortunately, the alleged outcomes were just not compared with one another (Yavari, Malakahmad, Sapari, & Yavari, 2018). It had been revealed that a medication's effect is really not specific to one level but rather includes several mechanisms of action. Due to this multi-level mode of action, gold-based nanomaterials exhibit exceptional activity not only against sensitive microorganism strains as well as against extremely resistant microorganism strains. It has been demonstrated that gold-based nanomaterials will disrupt microorganism metabolic processes, act with desoxyribonucleic acid, increase the protoplasm membrane porosity, etc. (Yallappa et al., 2017).

On the opposite hand it had been determined resistance to ionic gold. Despite the actual fact, that resistance to ionic gold originating from the power of microorganism to scale back Au+ to less noxious oxidation number or from active outflow of Au+ from the cell was rumored, no knowledge proving resistance to aluminous conductor nanoparticles were printed. Naturally, the medicinal drug impact of gold and gold based mostly nanoparticles depends on particle morphology and surface characteristics (Yallappa et al., 2017). Hence, it's necessary to seek out nanoparticles by the means that of size, form and surface modification applicable to be used within the biological applications. Gold NPs may be ready many various ways in which however wet chemical reduction ways unambiguously predominate (Wypij, Świecimska, et al., 2018). AuNPs may be ready by the reduction of either, soluble and insoluble gold compounds. Typical artificial methodology relies on the reduction of caustic by Na borohydride that is one in all the strongest reducing agents and thus little conductor NPs square measure created. However, a good range of milder reducing agents may be used for the assembly of gold NPs with numerous sizes, size distributions, shapes and morphologies (Wypij, Czarnecka, et al., 2018).

8. Gold Nanoparticles and DNA Repair

A cell predicts and fixes damage to the DNA that encodes its genes using different techniques for DNA repair. During the DNA repair mechanism, the gene P53 is linked to base correction of double-stranded breaks and nucleotide excision repair (Alhmoud, Woolley, Al Moustafa, & Malki, 2020). Following DNA damage, o ribonucleotide reductase which is important to repair, p53 induction can also transcribe p53R2 and leads to increase in 3-methyladenine an enzyme required for BER (Vlachostergios, Patrikidou, Daliani, Papandreou, & medicine, 2009). Permanent DNA damage accumulates in the cell which can lead to tumor formation and also damaged the neighbor cell in such type of DNA damage the normal repair processes fail to accrue and the mechanism of cellar apoptosis occurred (D, B, & Abrahamse, 2019).

The mechanism of DNA repair is mainly started after a set of cellular divisions in response to DNA deletion and cells either age or self-destructs through apoptosis due to damage that could not be repaired. This process is known as “Hay flick limit” (Effros & Walford, 1984). INK4a/ARF is the positive regulator of p53 stability, has shown to have increased p53 transcriptional action (Balakrishnan et al., 2017). The telomere restriction in the genetic code is halted by overexpression of the protein and downregulated when p53 is activated at a high expression level.

9. Chemotherapy by Using Gold Nanoparticles

The use of nanomaterials for chemotherapeutic agents was gained the fascination of scientists. Metal nanoparticles have shown excellent outcomes in the chemotherapy of cancer (Shreyash, Sonker, Bajpai, & Tiwary, 2021; Surapaneni, Bashir, & Tikoo, 2018). These particles were discovered to inflict significantly less toxicity on normal cells in addition to exhibiting cell growth inhibition toward many types of cancer cells (Safdar et al., 2019; Shreyash et al., 2021; Suk, 2005). Apoptosis induction is a primary target for cancer medications (El-Kassas & El-Sheekh, 2014; Emerich & Thanos, 2003), and such effects are readily represented by caspase research (de Oliveira Goncalves, Vieira, Levy, Bydlowski, & Courrol, 2020).

Additionally, the tumour suppressor p53 (Safdar, Ozaslan, Junejo, Channa, & Sciences, 2021) plays a crucial part in regulating cellular death signalling through the effects of gold nanoparticles. On the other side, breast cancer cells have high levels of NF-B, which is known to operate against p53 (Safdar et al., 2021). Therefore, inhibiting NF-B may be a target for chemotherapy. Additionally, the p53 and NF-kB pathways demonstrated the precise mechanism by which various medications and materials affect a variety of cellular processes, including apoptosis, development, and cancer (Hwang et al., 2012). Following the targeted gene alterations that rendered the p53 gene inactive and contributed to constitutive NF-kB activation in many malignancies (Hwang et al., 2012). There is a need for particular nano-drugs that can function in tandem with medications that can selectively activate p53 or inhibit NF-kB, despite the fact that some of these drugs are already on the market. Therefore, the NF-kB pathway and p53 activation are key targets for the creation of novel cancer medications (Hwang et al., 2012). Therefore, it is important to do new findings for synthesize and analyses of Au(0)NPs based on antibiotics to target p53 and NF-kB concurrently by MTT, relative gene and protein expressions on SKBR3 breast cancer cells. This may open new endeavours for new researchers.

10. Future Prospective, and Recommendations of Nanotechnology

The world is undergoing a technological revolution. All facets of our existence, including communications, health, and transportation, have undergone changes. It is important to say that "what was science fiction yesterday is science today". We are now developing our skills in every branch of science, including physics, chemistry, biology, and engineering. That specifically connected to space technology, constructing smart cities and new manufacturing hubs, as well as inventing quantum and artificial intelligence technology. Though the extremely small physical components of change known as nanotechnologies, which are fueling the revolution, the tremendous pace of technological development is abundantly visible. Although there are various applications for nanotechnology, but few of them are establishing the foundation for our future: Nanomedicine, Materials Science, and Device.

REFERENCES

Alhmoud, J. F., Woolley, J. F., Al Moustafa, A.-E., & Malki, M. I. J. C. (2020). DNA damage/repair management in cancers. *12*(4), 1050.

Balakrishnan, S., Mukherjee, S., Das, S., Bhat, F. A., Raja Singh, P., Patra, C. R., & Arunakaran, J. (2017). Gold nanoparticles-conjugated quercetin induces apoptosis via inhibition of EGFR/PI3K/Akt-mediated pathway in breast cancer cell lines (MCF-7 and MDA-MB-231). *Cell Biochem Funct, 35*(4), 217-231. doi:10.1002/cbf.3266

Bayda, S., Adeel, M., Tuccinardi, T., Cordani, M., & Rizzolio, F. (2019). The history of nanoscience and nanotechnology: from chemical–physical applications to nanomedicine. *Molecules, 25*(1), 112.

D, R. M., B, P. G., & Abrahamse, H. (2019). Enhancing Breast Cancer Treatment Using a Combination of Cannabidiol and Gold Nanoparticles for Photodynamic Therapy. *Int J Mol Sci, 20*(19). doi:10.3390/ijms20194771

de Oliveira Goncalves, K., Vieira, D. P., Levy, D., Bydlowski, S. P., & Courrol, L. C. (2020). Uptake of silver, gold, and hybrids silver-iron, gold-iron and silver-gold aminolevulinic acid nanoparticles by MCF-7 breast cancer cells. *Photodiagnosis Photodyn Ther, 32*, 102080. doi:10.1016/j.pdpdt.2020.102080

Effros, R. B., & Walford, R. L. J. H. i. (1984). T cell cultures and the Hayflick limit. *9*(1), 49-65.

El-Kassas, H. Y., & El-Sheekh, M. M. (2014). Cytotoxic activity of biosynthesized gold nanoparticles with an extract of the red seaweed Corallina officinalis on the MCF-7 human breast cancer cell line. *Asian Pac J Cancer Prev, 15*(10), 4311-4317. doi:10.7314/apjcp.2014.15.10.4311

Emerich, D. F., & Thanos, C. G. (2003). Nanotechnology and medicine. *Expert opinion on biological therapy, 3*(4), 655-663.

Hwang, S. G., Park, J., Park, J. Y., Park, C. H., Lee, K.-H., Cho, J. W., . . . Seong, J. Y. (2012). Anti-cancer activity of a novel small molecule compound that simultaneously activates p53 and inhibits NF-κB signaling.

Khadka, P., Haque, M., Krishnamurthi, V. R., Niyonshuti, I., Chen, J., & Wang, Y. (2018). Quantitative Investigations Reveal New Antimicrobial Mechanism of Silver Nanoparticles and Ions. *Biophysical Journal, 114*(3), 690a.

Kora, A. J., & Rastogi, L. (2013). Enhancement of antibacterial activity of capped silver nanoparticles in combination with antibiotics, on model gram-negative and gram-positive bacteria. *Bioinorganic chemistry and applications, 2013*.

Kumar, M., Bansal, K., Gondil, V. S., Sharma, S., Jain, D., Chhibber, S., . . . Wangoo, N. (2018). Synthesis, characterization, mechanistic studies and antimicrobial efficacy of biomolecule capped and pH modulated silver nanoparticles. *Journal of Molecular Liquids, 249*, 1145-1150.

Li, N., Zhao, P., & Astruc, D. (2014). Anisotropic gold nanoparticles: synthesis, properties, applications, and toxicity. *Angewandte Chemie International Edition, 53*(7), 1756-1789.

Logeswari, P., Silambarasan, S., & Abraham, J. (2015). Synthesis of silver nanoparticles using plants extract and analysis of their antimicrobial property. *Journal of Saudi Chemical Society, 19*(3), 311-317.

Maráková, N., Humpolíček, P., Kašpárková, V., Capáková, Z., Martinková, L., Bober, P., . . . Stejskal, J. (2017). Antimicrobial activity and cytotoxicity of cotton fabric coated with conducting polymers, polyaniline or polypyrrole, and with deposited silver nanoparticles. *Applied Surface Science, 396*, 169-176.

Michailidis, M., Sorzabal-Bellido, I., Adamidou, E. A., Diaz-Fernandez, Y. A., Aveyard, J., Wengier, R., . . . D'Sa, R. A. (2017). Modified Mesoporous Silica Nanoparticles with a Dual Synergetic Antibacterial Effect. *ACS applied materials & interfaces, 9*(44), 38364-38372.

Minhas, F. T., Arslan, G., Gubbuk, I. H., Akkoz, C., Ozturk, B. Y., Asıkkutlu, B., . . . Ersoz, M. (2018). Evaluation of antibacterial properties on polysulfone composite membranes using synthesized biogenic silver nanoparticles with Ulva compressa (L.) Kütz. and Cladophora glomerata (L.) Kütz. extracts. *International journal of biological macromolecules, 107*, 157-165.

Niedermeyer, W. H. (2018). Compositions and methods for treating plant diseases: Google Patents.

Patra, J. K., Das, G., Fraceto, L. F., Campos, E. V. R., Rodriguez-Torres, M. d. P., Acosta-Torres, L. S., . . . Sharma, S. J. J. o. n. (2018). Nano based drug delivery systems: recent developments and future prospects. *16*(1), 1-33.

Safdar, M., Junejo, Y., & Balouch, A. (2015). Efficient degradation of organic dyes by heterogeneous cefdinir derived silver nanocatalyst. *Journal of Industrial and Engineering Chemistry, 31*, 216-222.

Safdar, M., & Özaslan, M. (2022). Effects of gold nanoparticles on SKBR3 breast cancer and CRL-4010 non cancer cells. *Zeugma Biological Science, 3*(1), 1-6.

Safdar, M., Ozaslan, M., Junejo, Y., Channa, I. S. J. T., & Sciences, E. H. (2021). Cytotoxic and anticancer activity of a novel synthesized tet-AuNPs simultaneously activates p53 and inhibits NF-kB signaling in SKBR3 cell line. 1-8.

Safdar, M., Qumar, G. M., Saravanan, M., Khailany, R. A., Ozaslan, M., Gondal, M. A., . . . Junejo, Y. J. J. o. C. S. (2019). Synthesis and characterization of Cefditoren capped silver nanoparticles and their antimicrobial and catalytic degradation of Ibuprofen. *30*(6), 1663-1671.

Shreyash, N., Sonker, M., Bajpai, S., & Tiwary, S. K. (2021). Review of the Mechanism of Nanocarriers and Technological Developments in the Field of Nanoparticles for Applications in Cancer Theragnostics. *ACS Appl Bio Mater, 4*(3), 2307-2334. doi:10.1021/acsabm.1c00020

Suk, K. J. C. E. I. (2005). Role of caspases in activation-induced cell death of neuroglia. *1*(1), 43-50.

Surapaneni, S. K., Bashir, S., & Tikoo, K. (2018). Gold nanoparticles-induced cytotoxicity in triple negative breast cancer involves different epigenetic alterations depending upon the surface charge. *Sci Rep, 8*(1), 12295. doi:10.1038/s41598-018-30541-3

Turkevich, J., Stevenson, P. C., & Hillier, J. (1951). A study of the nucleation and growth processes in the synthesis of colloidal gold. *Discussions of the Faraday Society, 11*, 55-75.

Vijayakumar, M., Priya, K., Nancy, F., Noorlidah, A., & Ahmed, A. (2013). Biosynthesis, characterisation and anti-bacterial effect of plant-mediated silver nanoparticles using Artemisia nilagirica. *Industrial Crops and Products, 41*, 235-240.

Vijayan, R., Joseph, S., & Mathew, B. (2018). Augmented antimicrobial, antioxidant and catalytic activities of green synthesised silver nanoparticles. *Materials Research Express*.

Vlachostergios, P. J., Patrikidou, A., Daliani, D. D., Papandreou, C. N. J. J. o. c., & medicine, m. (2009). The ubiquitin-proteasome system in cancer, a major player in DNA repair. Part 2: transcriptional regulation. *13*(9b), 3019-3031.

Wypij, M., Czarnecka, J., Świecimska, M., Dahm, H., Rai, M., & Golinska, P. (2018). Synthesis, characterization and evaluation of antimicrobial and cytotoxic activities of biogenic silver nanoparticles synthesized from Streptomyces xinghaiensis OF1 strain. *World Journal of Microbiology and Biotechnology, 34*(2), 23.

Wypij, M., Świecimska, M., Czarnecka, J., Dahm, H., Rai, M., & Golinska, P. (2018). Antimicrobial and cytotoxic activity of silver nanoparticles synthesized from two haloalkaliphilic actinobacterial strains alone and in combination with antibiotics. *Journal of Applied Microbiology*.

Yallappa, S., Deepthi, D., Yashaswini, S., Hamsanandini, R., Chandraprasad, M., Kumar, S. A., & Hegde, G. (2017). Natural biowaste of Groundnut shell derived nano carbons: Synthesis, characterization and itsin vitro antibacterial activity. *Nano-Structures & Nano-Objects, 12*, 84-90.

Yavari, S., Malakahmad, A., Sapari, N. B., & Yavari, S. (2018). Fullerene C60 for enhancing phytoremediation of urea plant wastewater by timber plants. *Environmental Science and Pollution Research*, 1-13.

Zada, S., Ahmad, A., Khan, S., Iqbal, A., Ahmad, S., Ali, H., & Fu, P. (2018). Biofabrication of gold nanoparticles by Lyptolyngbya JSC-1 extract as super reducing and stabilizing agents: Synthesis, characterization and antibacterial activity. *Microbial Pathogenesis, 114*, 116-123.

Zheng, T., Sip, Y. Y. L., Leong, M. B., & Huo, Q. (2018). Linear self-assembly formation between gold nanoparticles and aminoglycoside antibiotics. *Colloids and Surfaces B: Biointerfaces, 164*, 185-191.

ABOUT THE AUTHORS

Muhammad SAFDAR, PhD, is a Lecturer/officer in-charge of Breeding and Genetics at Cholistan University of Veterinary and Animal Sciences (CUVAS), Bahawalpur, Pakistan. He holds a PhD in Molecular Biology and Genetics from Gaziantep University, Turkey. His main areas of interest are molecular genetics, nanomedicine, molecular biology, biotechnology and their applications. He also works as the Senior Librarian at CUVAS, Bahawalpur.

E-mail: msafdar@cuvas.edu.pk , **ORCID:** 0000 0002 3720 2090

Yasmeen JUNEJO, PhD, is an Assistant Professor of Physiology and Biochemistry at Cholistan University of Veterinary and Animal Sciences (CUVAS), Bahawalpur, Pakistan. He holds a PhD in Analytical Chemistry from Sindh University, Jamshoro, Pakistan. His main areas of interest are analytical chemistry, nanomedicine, nanostructures, nanobiotechnology and their applications.

E-mail: yasmeen@cuvas.edu.pk , **ORCID:** 0000 0002 3720 3214

Prof. Dr. Mehmet ÖZASLAN received his PhD in 1995 Institute of Natural Sciences at Cukurova University, Turkey. He is a Professor in Molecular Biology and Genetics. His research interests are included Cancer Genetics, Molecular Virology, Molecular Genetics, Microbiology, and Genetic mutations etc. He has published more than 200 research articles in national and international well reputed journals. He also has written many book chapters as well as edited books. He is an editor and editor in chief of many well reputed national and international journals.

E-mail: ozaslanmd@gantep.edu.tr , **ORCID:** 0000 0001 9380 4902

To Cite This Chapter

Junejo, Y., Safdar, M. & Özaslan, M. (2022). Methods for manufacturing of gold nanoparticles and their applucations. In M. Özaslan, *Current Studies in Health and Life Sciences 2022.* (pp. 20-26).