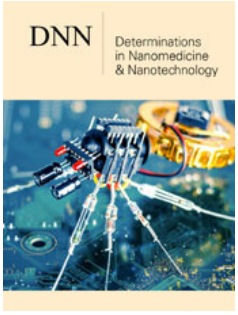
Crimson Publishers
Wings to the Research

Mini Review

Bio-Compatibility Advantages of Silver Nanoparticles Fabricated on the Ground of Synthetic Fulvic and Humic Acids

Minaev BF*, Litvin VA and Minaeva VA

Bohdan Khmelnytsky National University, Ukraine



***Corresponding author:** Minaev BF, Bohdan Khmelnytsky National University, Cherkasy 18031, Ukraine

Submission: January 29, 2022
Published: March 01, 2022

Volume 2 - Issue 4

How to cite this article: Minaev BF, Litvin VA, Minaeva VA. Bio-Compatibility Advantages of Silver Nanoparticles Fabricated on the Ground of Synthetic Fulvic and Humic Acids. Determ in Nanomed & Nanotech. 2(4). DNN. 000541. 2022.

Abstract

Silver and gold nanoparticles are synthesized in our group on the basis of synthetic Humic Substances (HSs) using them as stabilizing and reducing agents. The nanosynthesis process is optimized controlling concentration of synthetic HS's, metal salts, sodium hydroxide and temperature by means of UV–visible absorption in order to attain better yield, controlled size and stability of nanoparticles. At the optimal reaction conditions the concentrated noble metal colloids are obtained with a high yield which are stable during years. Combination in one nano-object of the nanosized metal core and biologically active matrix of organic humic polymer provides a nice perspective for creation of new class of multifunctional drugs with synergetic enhancement of various therapeutic properties. Penetration through many membranes appends to nanoparticles a good vehicle property and provides their potential in drug delivery. But their intrinsic foreignness to living cells and attendant toxicity still hinder the broader silver nanoparticles (AgNPs) implementions in clinics. Nanoparticle's bio-conjugation with amino acids and proteins permits to diminish AgNP toxicity and open the door to their clinical applications. The silver nanoparticles fabricated with synthetic fulvic, and humic acids have many advantages in comparison with the natural analogous of AgNP corona substances.

Keywords: Nanoparticles; Synthetic fulvic; Humic acids; Temperature; Polymer; Multifunctional drugs

Abbreviations: HSs: Humic Substances; ROS: Reactive Oxygen Species

Introduction

Nanoparticles definition: Silver Nanoparticles (AgNPs) nowadays have found numerous implementions in various field of natural sciences from pharmaceutics to molecular electronics and renewable-energy sources [1-3]. The surface plasmon resonance and other physico-chemical size-tunable characteristics of silver and gold nanoparticles provide their wide applications in nano-photonics, nano-diagnostics and therapeutical practice. The therapeutic properties of humic substances are well known and attract considerable attention in medicine and veterinary sciences [4-9]. They possess antiviral, antimicrobial, estrogenic, anti-inflammatory and profibrinolytic activities [3]. Number of medical studies indicate that humic substances, especially fulvic acids, possess the properties to protect against cancer and various viruses [9,10]. On the other hand, natural HSs have found applications in nanoscience as a new type of potential template for the formation of inorganic nanoclusters [7,11]. The AgNPs are the most broadly explored nanomaterials in nutrition, cosmetics, medicine inspite of their contemporary adverse effects on living creatures [3]. The contradiction between numerous benefits and some undesirable negative results strongly constrains the AgNPs applications in nano-medicine. Chemically fabricated AgNPs with synthetic HSs produce conformational strains and deformities among intracellular proteins since the fragile amino acid scaffold surface undergoes some distortions, which become targets for readily oxidation at typical cellular physiological conditions of aerobic metabolism with various Reactive Oxygen Species (ROS) [12-16]. The ROS can induce several cytotoxic deleterious effects leading to oxidative stress [6,16].

Thus, the AgNPs toxicity in respect to alive biosystems, which is entirely inherent to all nanoparticles, limits the wide AgNPs applications in medicine. It became clear now [5,6] that the effective implementions of AgNPs in nanopharmaceutics requires conjugation of the NP surface with biological molecules and tissues, which will enhance and stimulate biocompatibility and bio-acceptability of Ag-based nano-species. Masri et al. [5] have shown recently that AgNP conjugation enhances medical antibacterial effectiveness of two clinical drugs: Cephradine and Vildagliptin conjugated with AgNP show that nanoparticle conjugation of both clinically approved drugs strongly enhances antibacterial potential to *Bacillus cereus, Klebsiella pneumonia, Streptococcus pyogenes* of both nanocomposites in comparison to the free drugs alone. The antibacterial assay tests against a number of Gram-negative and Gram-positive human pathogens including methicillin-resistant *Staphylococcus aureus* bacteria demonstrate good efficacy of the AgNP drugs conjugation [5].

Mechanisms of bio-compatibility and bio-stability

AgNP production as an integral part of the modern nano bio-interface includes a number of natural organic substances for NP corona fabrication. Humic substances represent a reactive class of the natural aqueous and soil compounds which are a product of selective degradation of plant biomolecules. The HSs are amorphous, polydispersed, acidic, hydrophilic polymers being classified according to pH-dependent solubility in water; these are insoluble at low pH humic acids and fulvic acid-the lower molecular weight member, which is soluble at all pH. We do not consider humin, which is insoluble at all pH [2]. Few implementations of natural HSs (extracted from different soil and aqueous sources) in the AgNP synthesis was known before our studies [1]. Synthetic mechanism of silver ions reduction by natural HSs and properties of the obtained AgNP strongly depends on the source of natural HS extraction [7,8]. Heterogeneity of of natural HSs structure whose composition depends upon the source of the soil and the methods of extraction prevents a wide application of AgNP synthesized on the ground of humic substances in medical practice. The use of synthetic HSs, which mimic physicochemical properties of the natural materials secures the important standardization problem in pharmaceutics. At the same time implication of synthetic HSs for noble metal nanoparticles provides possibility for further efforts in bio-compatibility and bio-stability of synthesized AgNP. Upon contact with biological cellular liquids the AgNP surface absorbs reportedly protein species and other components of proteinaceous environment acquiring *in vivo* steadiness [5]; this provides nanoparticle with benevolent bio-compatibility and bio-stability [6]. Amino acids are able to form coordination link with silver ions through the functional groups such as –COOH, -NH_2, -SH, -OH and carbonyl functionality [6]. This could be used at the whole process of AgNP synthesis. Our detailed kinetic studies of HS and AgNP synthesis [1,2,16,17] afford us to produce the target fabrication of bio-compatible nanoparticles. Hydroxyl groups of fulvic acids [2-4] can be also used for a special purpose bio-conjugation with amino acids. The strict control of the AgNP synthesis conditions with synthetic HSs allows us to receive a product with the desirable established and reproduced properties [1,2,16,17]. The size, morphology and crystallinity of the fabricated AgNPs have been determined by FTIR and UV-visible spectroscopy, by transmission electron microscopy and X-ray diffraction analysis [16,17].

Conclusion

The phenomenon of bio-conjugation for AgNPs became recently quite important in the field of drug delivery and nanotechnology advancement in medicine. The biomolecule-conjugated AgNPs present operable solutions for tedious clinical complications of the present era, such as multidrug resistance, designing of pharmaceuticals with improved bioavailability, superior drug delivery vehicles and in situ bio imaging of important metabolites that utilize the biomolecule-anchored surface engineered AgNPs. We demonstrate the use of synthetic HSs in the synthesis of AuNPs, where unprecedented control of particle size and shape is achieved by varying the experimental conditions. Our results suggest that the pH value (e.g., addition of NaOH) in the reaction system provides a great influence on the yield of generated AgNPs and on their size. The ratio Ag/HSs strongly influences the shape of silver nanoparticles. We have found, that the basic factors determining the sizes, forms and stability of AgNPs fabricated with synthetic HSs and produced from various phenolic precursors are practically the same. It allows us to use the studied approaches to the synthesis of AgNPs with the use of substances with other possible phenolic precursors and amino acids.

References

1. VA Litvin, Galagan RL, Minaev BF (2012) Kinetic and mechanism formation of silver nanoparticles coated by synthetic humic substances. Colloids and Surfaces A: Physicochemical and Engineering Aspects 414: 234-243.
2. Litvin VA, Minaev BF (2013) Spectroscopy study of silver nanoparticles fabrication using synthetic humic substances and their antimicrobial activity. Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 108: 115-122.
3. A-C Burdusel O, Gherasim AM, Grumezescu L, Mogoanta A, Ficai EA (2018) Biomedical applications of silver nanoparticles: An up-to-date overview. Nanomaterials 8(9): 681.
4. Litvin, VA Minaev BF (2014) The size-controllable, one-step synthesis and characterization of gold nanoparticles protected by synthetic humic substances. Materials Chemistry and Physics 144 (1-2): 168-178.
5. Masri A, Anwar A, Ahmed D, Siddiqui RB, Muhammad RS, et al. (2018) Silver nanoparticle conjugation enhanced antibacterial efficacy of clinically approved drugs cephradine and vildagliptin. Antibiotics 7(4): 100.
6. Prasher P, Sharma M, Mudila H, Gaurav G, Sharma AK, et al. (2020) Emerging trends in clinical implications of bio-conjugated silver nanoparticles in drug delivery. Colloid and Interface Science Communications 35: 100244.
7. Litvin VA, Minaev BF, Baryshnikov GV (2015) Synthesis and properties of synthetic fulvic acid derived from hematoxylin. J Mol Structure 1086: 25-33.
8. Litvin VA, Galagan RL, Minaev BF (2012) Synthesis and properties of synthetic analogs of natural humic acids. Rus J Appl Chemistry 85(2): 296-302.

9. Klöcking R, Helbig B (2005) In: Steinbüchel A, Marchessault RH (Eds.), Biopolymers for Medical and Pharmaceutical Applications, Wiley-VCH, USA, 1: 1-13.

10. Rensburg CE, Dekker J, Weis R, Smith TL, Rensburg J, et al. (2002) Investigation of the anti-hiv properties of oxihumate. Chemotherapy 48(3): 138-143.

11. Vinayagam R, Selvaraj R, Arivalagan P, Varadavenkatesan T (2020) Synthesis, characterization and photocatalytic dye degradation capability of *Calliandra haematocephala*-mediated zinc oxide nanoflowers. J Photochem Photobiology B: Biology 203: 111760.

12. Sharma Y, Kawatra A, Sharma V, Divya D, Sulochana K, et al. (2021) *In-vitro* and in-silico evaluation of the anti-chikungunya potential of *Psidium guajava* leaf extract and their synthesized silver nanoparticles. Virus Disease 32(2): 260-265.

13. Minaev BF (2019) How cofactor-free oxygenases can overcome spin prohibition in substrates oxygenation by dioxygen. Chemical Physics 521: 61-68.

14. Minaev BF, Lunell S, Kobzev GI (1994) Collision-Induced intensity of the $b_1\Sigma g^+ - a_1\Delta g$ transition in molecular oxygen: Model calculations for the collision complex O_2+H_2. Internat J Quant Chem 50(4): 279-292.

15. Minaev BF (2021) Magnetic torque in superoxide ion is the main driving force of dioxygen activation in aerobic life. Biomedical Journal of Scientific & Technical Research 38(4): 30462-30472.

16. Litvin VA, Minaev BF, Galagan RL, Baryshnikov GV, Ågren H (2019) Growth of silver nanoparticles using polythiocyanatohydroquinone in aqueous solution. Acta Chimica Slovenica 66(2): 427-434.

17. Litvin VA, Minaev BF, Baryshnikov GV (2019) Experimental and theoretical study of the mechanism formation of silver nanoclusters in the reduction reaction of Ag^+ ions by alizarin solution. Colloid and Interface Science Communications 29: 47-54.

