JOURNAL OF NANO- AND ELECTRONIC PHYSICS *ЖУРНАЛ НАНО- ТА ЕЛЕКТРОННОЇ ФІЗИКИ*
Vol. **15** No 4, 04015(5pp) (2023) Том **15** № 4, 04015(5cc) (2023)

Analysis of Silver Nanoparticles as Carriers of Drug Delivery System

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(Received 15 June 2023; revised manuscript received 18 August 2023; published online 30 August 2023)

Nanotechnology has advanced significantly over the last decade and has found several uses in fields as diverse as medical, pharmaceuticals, microelectronics, aerospace, and the food industry. The use of nanoparticle (NP) drug carriers has been investigated, and this method offers several benefits. Some of these benefits include the controlled and targeted release of loaded or coupled drugs, as well as an improvement in the bioavailability of the drug. However, they also have certain drawbacks, such as their in vivo toxicity, which affects all organs, including the healthy ones, and the overall benefit of the illness therapy, which might be insignificant or limited. Due to their unique physical, chemical, and optical characteristics, AgNP have attracted a lot of attention in recent years. These NP have several potential uses, including drug delivery. Methods that get around these problems are crucial since traditional cancer chemotherapy has several drawbacks, including limited bioavailability and the need for high dosages that have side effects. The study examines AgNP as a drug delivery system for the treatment of cancer. The paper also examines the most recent developments in the use of AgNP for the delivery of anticancer medications and their impact on antitumor effects. It is also observed that silver nano particles can characterize their physicochemical properties and determine the presence of any potential toxicity.

Keywords: Silver Nanoparticles, Drug Delivery System, Nanotechnology in Medicine

DOI: 10.21272/jnep.15(4).04015 PACS numbers: 47.63.mh, 87.19.xj

1. INTRODUCTION

One of the most difficult illnesses to treat is cancer, which is defined by the uncontrolled division of altered cells [1]. Genetic dysregulation or mutations brought on by acute or long-term exposure to xenobiotics or environmental contaminants may be the etiology of this condition. A process known as metastasis allows cancer cells to move to several organs. Chemotherapy, surgery, and radiation therapy are the standard therapeutic approaches used to treat cancer [2]. According to the pathological phases and scientific symptoms of a disease, these treatments are often utilized. Despite improvements in treatment methods, chemotherapy side effects are common and patients' long-term survival rates are dismal. Chemotherapy medicines often have low water solubility. Due to the decreased biocompatibility, hydrophobic medicines need greater doses to reach therapeutic concentrations. Additionally, significant systemic toxicity and decreased medication bioavailability are also consequences of poor hydro solubility [3]. Additionally, chemotherapy medications often have minimal selectivity, severely harm healthy tissues, and thus result in unpleasant effects. The treatment for malignancies that eventually cease reacting to chemotherapy or radiation therapy may include combining the pharmacological effects of anticancer drugs with the anticancer integral aspect of AgNPs. The AgNPs have inherent various strategies are used to achieve antibacterial and anticancer effects [4]. This causes the deregulation of crucial cellular processes, which causes increased cell death and damage. Employed nowadays when they are placed in food containers or antiseptic medical dressings. A prospective cancer therapy strategy would include using AgNPs to deliver anticancer medications to a tumor location where the AgNPs would then let go of medication "in-situ" and then begin acting after having been exposed to taken up by the cells [4-5].

Hence, in this research, we explain a few pedagogical ideas associated with using common NPs as medication delivery methods. The further portion of the article includes section 2 indicates the Literature survey, section 3 describes the nanocarriers for drug delivery, section 4 describes the silver nanoparticles methods, section 5 describes the anticancer drugs coupled to silver nanoparticles, and section 6 indicates the conclusion.

2. LITERATURE REVIEW

In [6], the many aspects of computer-aided drug development were discussed with an emphasis on anticancer drugs. The preclinical and clinical data gathered with these diverse medications are discussed in the review, along with any potential developments [7]. In

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The results were presented at the 3rd International Conference on Innovative Research in Renewable Energy Technologies (IRRET-2023)

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[8], suggests Electrostatic interaction with the negatively charged siRNA was made possible by the cationic polyamine backbone, the DexAMs' cyclodextrin content allowed for the formation of complexes and intracellular transport, absorption, Suberoylanilide Hydraemic Acid (SAHA) and erlotinib are examples of hydrophobic anticancer drugs. In [9], makes an effort to assemble several chemical alterations made to CS and highlight the results of the resulting nanocarriers, particularly in cancer treatment and medication delivery. In the article, extracellular biosynthesis of AgNPs from the Bacillus cereus (ATCC 14579) bacterial strain was the main objective. The article [10] presents the antibacterial and anticancer characteristics of AgNP, as well as their molecular routes, which have been highlighted in this study with careful consideration. The knowledge of AgNPs' pervasive use in commercial and healthcare items, biological technology, implants, environmental cleanup, and other areas is emphasized by a brief mention of a few of the applications of AgNPs that are not specifically related to those mentioned above. The article [11] provides micro environmental biology is hampered by the absence of targets for the metabolic clampdown, cytotoxicity, and genotoxicity mechanisms involved in tumor cellular heterogeneity. The fields of Molecular biology and chemical metabolomics are significant technologies that may be used to investigate specific, cellular proteins or genes and intermediates. In terms of anticancer therapy, chemical metabolomics has numerous benefits over genomes, transcriptomics, and proteomics. In [12], metal NPs (MNPs) have received a lot of attention because they have the potential to make important advances in the realm of medicine by strengthening the effectiveness of pharmaceuticals by site specificity, reducing multidrug resistance, and efficiently supplying therapeutic agents. The main methods of Synthesis AgNPs include techniques for the physical, chemical, and biological production of AgNPs, as well as their unique physiochemical characteristics [13].

In the article [14] against COVID-19, AgNPs might be used, although they are linked to toxicity. In this work, non-edible, agro-waste Hibiscus sabdariffa stems were used to create biogenic and biocompatible AgNPs. Under ideal reaction circumstances, Green AgNPs with a surface charge of around 20 MV and a diameter of about 17 nm were created as crystalline, face cubic-centered, spherical materials. Their lethal dosage for mice was four times more than that of the substance AgNPs. The nanostructured drug delivery system is this specific technique that permits the entry of a therapeutic nanostructured material into the body by managing the rate, timing, and location [12]. Materials are reduced to the nanoscale, and their physicochemical characteristics alter, and this might be beneficial in several biological applications [15].

In study [16], intends to further future studies on biomineralization-based cancer treatment. The impediment to clinically effective nanomaterial transformation may be solved by the rational design of nanoparticle medication delivery systems. The study [13] provides cancer therapies utilized today have unpleasant side effects, are ineffective, and are expensive, which are some of the key downsides of the treatments that are now accessible. The study of cancer apoptotic activity with an IC_{50} value was six times higher than the normal cell line. Moxifloxacin or gatifloxacin was functionalized with polydopamine, and the conjugates demonstrated enhanced Acinetobacter strain, pseudomonas, and Klebsiella pneumonia biofilms were all affected by the antibiofilm activity. A synergistic action was evident since the improved antibiofilm activity was much higher than that of the antibiotic alone or of polymerized AgNPs [17]. In [18], developed a new hydrogel with exceptional bactericidal activity by effectively creating galactic acid function AgNPs (GA-AgNPs) embedding into the network design of a biocompatible polysaccharide after utilizing a one-pot method. The study research examined MCF-7, HT-29, and HUH-7 cell lines of AgNPs, which were tested for their antibacterial properties against bacteria, fungal, and fungi strains of pathogens. The medicines it produces work better. Gold NP (AuNPs) and AgNP are produced by physical, chemical, and biological processes. The review presents phyto-based AgNPs for anticancer and antiviral activities, as well as their likely mechanisms of action, which are further explored in this study. Critical reviews of green synthetic AgNPs made from several medicinal plant extracts for cancer and viral illness.

3. NANOCARRIERS FOR DRUG DELIVERY

The most popular drug administration methods include administering medications orally or subcutaneously, using standard Solids, liquids, dispersions, and solutions medicinal forms are examples of preparations (tablets, capsules, etc.). Although these preparations can occasionally have drawbacks, such as decreased efficacy because it can be challenging for a drug to reach its intended site of action exclusively because it circulates both diseased and good cells are impacted throughout the body, which might have major negative consequences.

Nanocarriers have many advantages over traditional drug delivery methods, including enhanced biodistribution, extended plasma half-life, and endothelial-mediated tailored drug delivery to the tumour microenvironment. The medication delivery methods based on nanocarriers are being employed against numerous tissue-containing malignant tumor types.

4. SILVER NANOPARTICLES

The two methods of "top to bottom" and "bottom to top" syntheses of AgNPs are typically used. The two synthesis methods for metallic NPs that involve chemical, physical, and biological methods are top to bottom and bottom to top. The creation of NPs frequently involves both physical and chemical processes. Both methods may be used to create AgNPs. The top-down approach, for instance, may be used to mechanically grind bulk metals and then stabilize the metal particles that are produced when colloidal protection agents are added. Using electrochemical processes, metal reduction, and breakdown in addition to the bottom-up approach.

4.1 Synthesis Methods

Metal precursors, reducing substances, and sustaining compounds are typically the three major components used in the production of AgNPs in solution. Boron hydride, sodium citrate, ascorbic acid, alcohol, and hydrazine compounds are some often used reducing agents. Using a flame aerosol approach, Silver concentration and density were precisely controlled during the production of AgNPs supported on nanostructured SiO_2.

4.2 Characterization Methods

A variety of both analytical and spectral methods are used to describe the nature, size, shape, distribution, stability or aggregation state, morphology, elemental content, and dispersity of NPs. Due to surface plasmon resonance, it is quite distinctive depending on the size, shape, and distribution of AgNPs. While bigger AgNPs exhibit distortion and wide peaks, the smaller, spherical AgNPs absorb at around 400 nm. Since the peaks begin to expand and lose strength as additional peaks at specific wavelengths arise when the material assembles, this is also a sign of the stability of AgNPs.

5. ANTICANCER DRUGS COUPLED TO SILVER NANOPARTICLES

AgNPs may be a unique technique for treating cancer from two perspectives because of their special qualities, they exhibit inherent anticancer activities also may be utilized as delivery systems for anticancer medications, allowing for therapy of dual treatment. In terms of the latter strategy, the previously described free anticancer chemicals don't compare well to the transport systems in many ways.

The works that were chosen for the current examination were chosen based on previously set inclusion and exclusion criteria. Only trials employing AgNPs in combination with anticancer pharmaceuticals were chosen for the review, quickly eliminating hundreds of manuscripts from the database search. Studies that included AgNPs in combination with naturally occurring compounds that have an anticancer effect, for instance, were not included since they were not pharmaceutical medications. A pharmaceutical anticancer agent was not coupled with this method, many of the papers that came up in the search results were about the effects of AgNPs' inherent anticancer properties in several cell lines.

5.1 Methotrexate Anticancer Drug

One of the first generations of anticancer medications to employ a folic acid analog was methotrexate (MTX). MTX is effective against a variety of cancers, including rheumatoid arthritis, osteosarcoma, breast and cervical cancer, leukemia, and hematologic malignancies. MTX is utilized in conjunction with other anticancer medications such as 5 fluorouracil and cyclophosphamide.

5.2 Doxorubicin Anticancer Drug

The biosynthesis-based method was used to produce AgNPs that were combined with the chemotherapy drug doxorubicin (NGO-AgNPs-PEG). The NGO was first created by combining concentrated sulfuric acid, potassium permanganate, and aqueous hydrochloric acid formulations. After stirring the NGO aqueous solution for up to 12 hours, it was filtered, put through a 30 minute ultrasonic treatment, and then freeze-dried.

Azadirachta indica leaves were cleaned, dried, and combined with high-purity water for distillation at 100 degrees Celsius for 15 minutes while being continuously stirred to create the aqueous extract of the leaves. Centrifuging the filtered extract at 7000 rpm for 15 minutes while it was still cold allowed it to be kept at 4 °C.

5.3 Folic Acid Anticancer Drug

Through electrostatic interactions between the positive costs of the drug particles and the carboxylic acid's effects on the opposing charges on the molecules of folic acid, finally, DOX molecules were joined to the coated nanoparticle. The folic acid receptor has a restricted distribution in normal tissues, but it is overexpressed in various malignancies.

5.4 Imatinib Anticancer Drug

Imatinib may interact with capping compounds derived from the complex natural product extract, according to one theory. This hypothesis should be checked since it was not supported. The authors concluded this IMAB release profile could be separated into two phases after performing certain drug release studies.

In the first stage, the drug was released abruptly for up to 40 hours, and the medication was progressively removed in the second stage. 80 hours of contact time in a releasing imitating environment, till a release of 86.56 ± 2.04 % phosphate-containing medium buffer, pH 7.4, 37 °C.

Fig. 1 shows the pattern after 80 hours of contact with phosphate buffer at 37 °C, the pattern of IMAB synthesis from IMAB-AgNPs.

It only observes that the cytotoxicity also increased with larger IMAB-AgNPs concentrations, becoming more prominent for lower levels of concentration.

Fig. 2 shows that the cytotoxicity increased along with the IMAB-AgNPs concentrations, becoming more prominent at higher concentration levels. In this work to completely comprehend how IMAB-AgNPs affect both cancer and healthy cells, this effort must include research with normal cells.

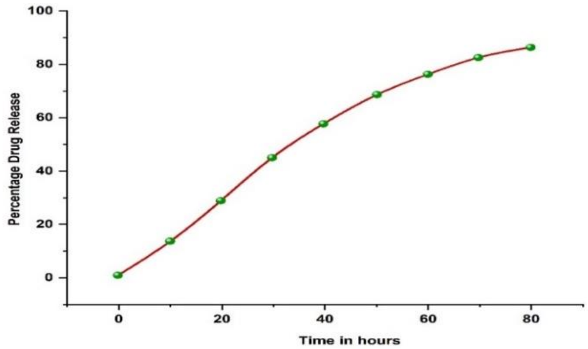

Fig. 1 – Pattern after 80 hours of contact with phosphate buffer at 37 °C, the pattern of IMAB synthesis from IMAB-AgNPs.

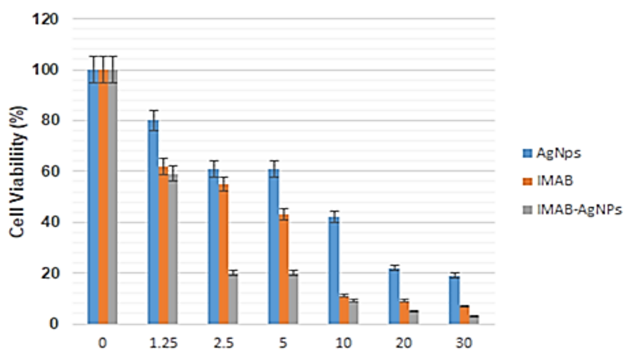

Fig. 2 – A comparison of the effects of varying doses AgNPs, IMAB-AgNPs, and free IMAB on MCF-7 cancer cells at various doses (0, 1.25, 2.5, 5, 10, 20, and 30 μM) and following a 24-hour incubation.

5.5 Gemcitabine Anticancer Drug

Gemcitabine's adverse effects might include fever, liver disease, and low levels of blood cell issues, and accumulation of fluid in or around the lungs. A comparison with the profile found in a free GEM solution was made as part of certain released drug studies of GEM-AgNPs. Similar release profiles were shown by both solutions which is shown in Fig. 3.

A kind of breast cancer cell MDA-MB-453 was used in cytotoxicity tests using AgNPs and GEM-AgNPs by the authors. They found that, up to a frequency, AgNPs had no effect relating to a kind of breast cancer cell MDA-MB-453 in terms of cytotoxicity of 6.25 μg/mL

Different levels of AgNPs coupled to the drug gemcitabine were synthesized to investigate the potential synergistic impact between them. The greatest proportion was set at 5.45 μg/mL, which represents similar to the level of AgNPs with proven cytotoxic-free outcomes.

The authors found a considerable with the concentrations of 40, 50, and 80.0 μM, there was an

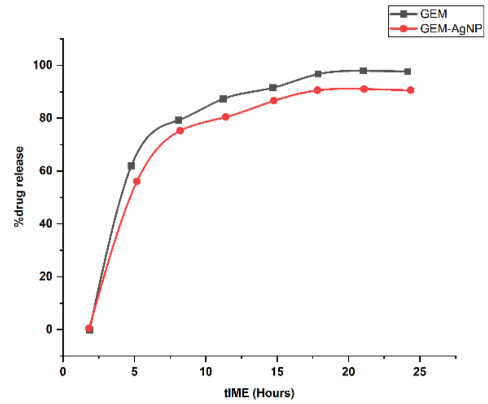

Fig. 3 – Profiles of GEM are released over 24 hours in a phosphate buffer solution with a pH of 7.4.

improvement in cytotoxicity (%). When they compared the findings comparing the outcomes of similar doses of free GEM and GEM-AgNPs. In actuality, the GEM-AgNPs obtained IC_{50} was lower than the free drug.

6. CONCLUSIONS

The potential advantages of adopting AgNPs as a significant nanomaterial in the medicinal and industrial sectors have been extensively recognized. AgNPs are developing as a next-generation application in several subfields of nanomedicine. It has looked at a wide range of research on silver nanomaterials to characterize their physicochemical properties, determine any potential toxicity, and learn more about their synthesis processes and mechanisms to find more promising oncology, personalized medicine, and pharmacology applications. The creation of this kind of nano system was also the subject of a dearth of investigations. With its lack of reliance on chemical reagents, simplicity, and environmental friendliness, the biosynthesis of AgNPs has been gaining importance. Three of the articles presented employed this methodology out of the total number. A synergistic interaction between AgNP and anticancer medications has been shown in the publications under analysis, enabling the use of lower dosages. Against many cancer cell types, the AgNP demonstrated exceptional anticancer efficacy. The different synthetic methods have a big impact on the AgNP's ability to cause cell death. Other than scaling up production, future difficulties in AgNP synthesis and release into the environment evaluate several prospective paths for future research to promote safer and more effective exploitation of these NP. Biological material of people and animals is not used in the work.

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Аналіз наночастинок срібла як носіїв системи доставки ліків

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За останнє десятиліття нанотехнології значно просунулися вперед і знайшли широке застосування в галузях медицини, фармацевтики, мікроелектроніки, аерокосмічної та харчової промисловості. Було досліджено використання носіїв ліків з наночастинок (НЧ), і цей метод пропонує кілька переваг, до яких відносяться контрольоване та цілеспрямоване вивільнення навантажених або пов'язаних ліків, а також покращення біодоступності препарату. Однак вони також мають певні недоліки, такі як їх токсичність in vivo, яка впливає на всі органи, включаючи здорові, і загальна користь від терапії захворювання, яка може бути незначною або обмеженою. Завдяки своїм унікальним фізичним, хімічним і оптичним властивостям НЧ Ag привернули багато уваги в останні роки. Ці наночастинки мають кілька потенційних застосувань, включаючи доставку ліків. Методи, які обходять ці проблеми, є вирішальними, оскільки традиційна хіміотерапія раку має кілька недоліків, включаючи обмежену біодоступність і потребу у високих дозах з побічними ефектами. Дослідження розглядає НЧ Ag як систему доставки ліків для лікування раку. У статті також розглядаються останні розробки у використанні НЧ Ag для доставки протипухлинних ліків та їх вплив на протипухлинну дію. Показано,що наночастинки срібла можуть характеризувати свої фізико-хімічні властивості та визначати наявність будь-якої потенційної токсичності.

Ключові слова: Наночастинки срібла, Система доставки ліків, Нанотехнології в медицині