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RESEARCH ARTICLE

Assessing Silver Nanoparticles' Antibacterial Activity in Dental Fillings: Effect on Bacterial Multiplication and Prospects for Improved Oral Health

Mu'ataz S. Al Hassan[1*], Zoubeir Tourki[2], Bouteina Ben Fraj[3]

[1,2]National School of Engineers of Sousse, Sousse, Tunisia
[1]Al Ayen University, Thi-Qar, Iraq
[1]Al-Shatrah University, Thi-Qar, Iraq
[3]Nanomaterials and Systems for Renewable Energy Laboratory, Research and Technology Center of Energy, Technoparc Borj Cedria, Hammam Lif, Tunisia

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***Corresponding Author:**

muataz@alayen.edu.iq

ABSTRACT

This study examines the impacts of adding different amounts (2%, 3%, 4%, and 5%) of silver nanoparticles to dental fillings. The dental fillings were analyzed before and during the introduction of silver nanoparticles to evaluate any alterations in bacterial proliferation. The findings suggest that increased concentrations of silver nanoparticles decrease bacterial growth in the samples. This discovery indicates that augmenting the proportion of silver nanoparticles has a substantial suppressive impact on bacterial proliferation. The observations emphasize the potential of silver nanoparticles as an antibacterial agent in dental materials, which has promising implications for enhancing dental treatments and oral health.

INTRODUCTION

The use of silver nanoparticles in dental fillings has attracted considerable interest because of its potential antimicrobial capabilities and capacity to improve dental materials' mechanical and antibacterial properties. Silver nanoparticles have distinctive characteristics, including a high surface area-to-volume ratio and enhanced reactivity, rendering them highly effective against various microorganisms[1,2,3,4,5] . These nanoparticles can be produced using several methods, and laser ablation is one of the primary procedures used for their synthesis[4] . Laser ablation enables the accurate production of silver nanoparticles, guaranteeing consistent size and even dispersion[6,7,8,9,10,11,12,13,14]. Researchers have recently investigated using silver nanoparticles in dentistry in tooth restorative materials [15]. Adding silver nanoparticles to dental fillings is believed to have antimicrobial effects, potentially reducing germs' growth and creating biofilms on dental restorations. Consequently, this may decrease the likelihood of tooth decay and enhance the durability of dental fillings [16]. This work utilized pulsed laser ablation to generate silver nanoparticles in dental fillings [17]. The objective is to examine the effects of different concentrations of silver nanoparticles on dental fillings' mechanical characteristics and antibacterial activity [18,19,20]. This research aims to enhance the performance and durability of dental materials by analyzing the impacts of incorporating silver nanoparticles. By doing so, it wants to add to the understanding of how nanotechnology might be utilized to improve patients' oral health [21,22,23].

MATERIALS AND METHODS

Silver

Belzer-Germany gave us silver metal plates of exceptional purity, measuring 99.999%. Subsequently, the plates underwent a sequence of procedures, including polishing, cleansing with ethanol and distilled water, and being divided into smaller fragments measuring 0.02 cm by 0.5 cm by 1 cm to meet the specifications of the experimental arrangement [16,24,25].

Table 2-1 presents the collective characteristics of Silver, as cited in [16].

Properties	
Electronic configuration	[Kr] 4d105S1
Atomic Number	47
Lattice	F.C.C
Density	10.49 g cm-3
Standard atomic weight	107.8682
Van Der Waals Radius	172 pm
Thermal Diffusivity	(300K) 174 mm2/s
Ionization Energy	731.0 kJ mol-1
Electric Resistivity	(20 C) 15.87 Ω. m
Melting Temperature	1235 K
Boiling Temperature	2435 K
Thermal Conductivity	429 W m-1 K-1
The absorption coefficient at 1064nm	30%

Distilled and Deionized Water

When creating samples and solutions for this inquiry, utilizing water that has undergone both distillation and deionization processes is essential. Despite its high purity level, the water may still include trace salt ions, dissolved gases, and other impurities. In order to address this problem, the Mansur Factory in Baghdad utilizes an ion exchange process to produce deionized water. This method effectively eliminates solid particles by utilizing filter sheets. Simultaneously, any dissolved gases are expelled through a violent boiling process, sustained at 100°C for 10 minutes[22,23,24,25,26]. Our laboratory employs additional protocols to ensure the utmost purity of the water used. We employ a dual-distillation method involving the repeated distillation of water in a glass device. Following meticulous and comprehensive preparation, we assess the pH level of the water, which regularly registers at around 7. In addition, we quantify the electrical resistance of the water, which is 5×10^6 ohms per centimeter. These measures are implemented to safeguard against potential water contamination and guarantee the highest level of quality in our experimental endeavors[24,26].

Dental fillings

Dental fillings are materials used to fill cavities or voids in teeth resulting from decay or other types of damage. The main goal of dental fillings is to repair and restore the shape and function of damaged teeth while protecting them from further deterioration. Dental fillings are available in several varieties, and their compositions vary depending on the type and materials used. The following are common components of dental fillings:

1. Filling materials: Dental fillings are composed of various materials. Common examples include metallic dental fillings, such as amalgam comprising mercury and Silver. These fillings are well-known for their durability and resistance to corrosion.

Composite dental fillings are composed of resin-based compounds mixed with a filler consisting of glass or ceramic. They provide desirable aesthetic results and effortlessly blend with natural teeth.

Ceramic dental fillings are made from either porcelain or ceramic materials. They are widely recognized for their ability to withstand stains and their long-lasting quality.

- Glass ionomer dental fillings are composed of glass and acrylic acid. They are commonly used in circumstances that involve regions with low stress-bearing capacity.

2. Dental fillings may require adhesives or bonding agents to ensure proper placement. These substances facilitate the bonding of the filling to the tooth structure.

3. Additional Filling Materials: In specific cases, supplemental materials like fluoride may be employed to prevent the formation of new cavities.

4. Ultraviolet Light (U.V. Sources): Ultraviolet light is employed to mend and harden composite dental fillings. It is used to start and strengthen the material.

The composition of dental fillings is contingent upon the particular type of filling and the patient's needs. The choice of filling type and materials is typically made in consultation with a dentist, considering factors such as the cavity's position in the mouth, aesthetic concerns, and the requirement for durability and longevity [23,24,25,26,27,28].

MICROBIOLOGICAL TEST

Results

The protocol for evaluating microorganisms in dental filling samples, including the inclusion of silver nanoparticles:

The procedure for examining bacteria in dental filling samples can be employed to study the influence of incorporating silver nanoparticles on bacterial proliferation. Silver nanoparticles possess antibacterial characteristics that can potentially inhibit bacterial development. The subsequent steps delineate the comprehensive protocol:

Collection of Samples:

Gather specimens from dental fillings created with varying concentrations of silver nanoparticles (2%, 3%, 4%, and 5%). The samples may originate from either experimental dental fillings or dental treatments.

Preparing the Equipment and Tools:

Make sure that all testing equipment is sanitary to avoid unintentional contamination. These items encompass test tubes, culture material, Petri plates, microscopes, and bacterial incubators.

Preparation of Culture Media:

Prepare an appropriate growth medium for bacterial culture, such as nutritional agar or other forms of medium that facilitate bacterial growth. A specialized medium can also be employed to examine particular strains of bacteria.

Inoculation Procedure:

Transfer the samples obtained from dental fillings onto the culture medium via inoculation. This can be accomplished by gently rubbing the sample on the surface of a Petri dish or by placing it in a test tube filled with a substance that promotes the growth of microorganisms. Employ aseptic methodologies to prevent the introduction of contaminants.

Incubation of Samples:

Transfer the samples treated with inoculum to an incubator set at 37 degrees Celsius, as this temperature is ideal for promoting the growth of most bacteria.

Surveillance and Progress Tracking:

After incubation, carefully examine for the presence of bacterial colonies. Analyze the development of colonies on Petri dishes or observe any alterations in the color of the culture media. Contrast the outcomes of samples with varying amounts of silver nanoparticles with a control sample lacking these additions.

Identification and Analysis:

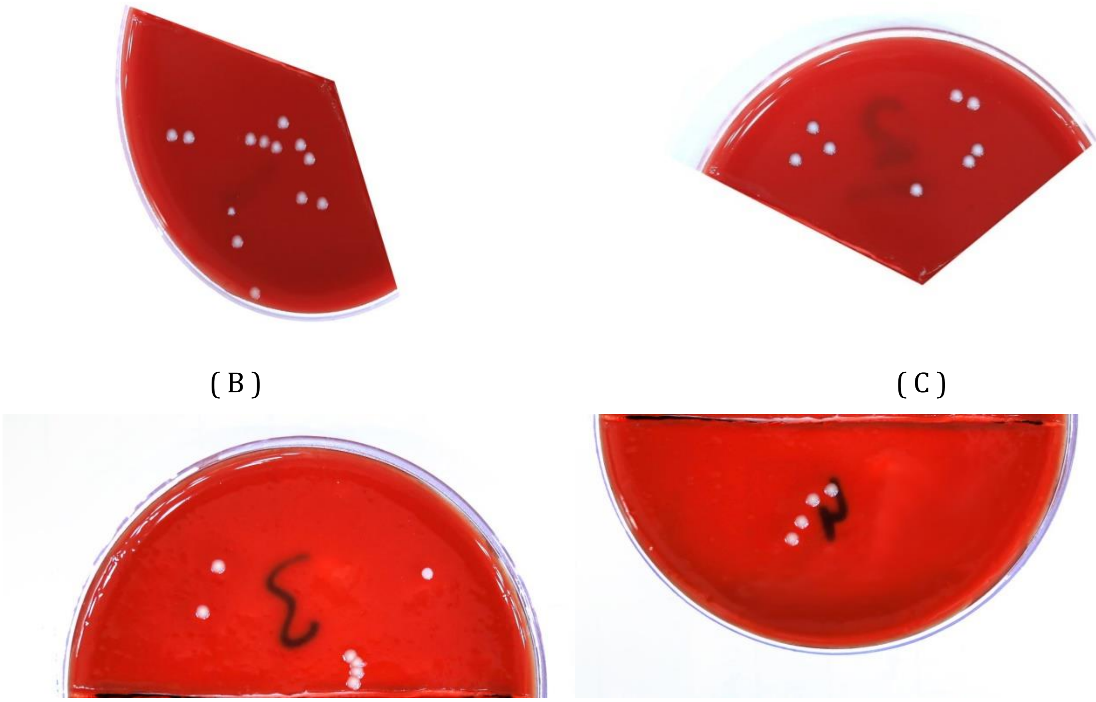
Differentiate between bacterial species by employing Gram staining or other chemical-reactive assays. Molecular assays can also be employed to identify distinct bacterial strains. Analyze the variations in bacterial proliferation in samples with different levels of silver nanoparticles. This study aims to demonstrate the influence of various concentrations on bacterial proliferation.

Documentation and Reporting:

Record the findings, encompassing bacterial growth's existence, classification, and levels. Contrast the samples containing silver nanoparticles with the ones that do not. Produce a comprehensive report that presents the findings and deductions concerning the impact of silver nanoparticles on the growth of germs in dental fillings.

Figure 3-12 illustrates the microbiological examination performed on dental fillings that contain nano silver, as shown below: (A) has a value of 0%, (B) has a value of 2%, (C) has a value of 3%, (D) has a value of 4%, and (E) has a value of 5%.

(A)



(B) (C)

(D) (E)

Figure 3-12 The microbiological test of dental fillings containing nano silver (A) at 0%, (B) at 2%, (C) at 3%, (D) at 4%, and (E) at 5%.

Analysis

The findings of the bacterial investigation indicate an inverse correlation between the concentration of silver nanoparticles in the samples and the abundance of identified bacteria. This research provides a clear demonstration of the recurring trend in question.The analysis of the reference sample indicated a significant abundance of bacteria, without the incorporation of any silver nanoparticle additions. This suggests that bacteria may proliferate unrestrictedly in these samples, which raises concerns over the possible hazards of infection or degradation. Analysis of Samples Containing Silver Nanoparticles: The researchers saw a progressive decrease in bacterial counts when examining samples containing silver nanoparticles at concentrations of 2%, 3%, 4%, and 5%. As the concentration of silver nanoparticles increases, the reduction in bacteria becomes more pronounced. Analysis and Conclusion: The negative correlation between bacterial growth and the concentration of silver nanoparticles implies that silver nanoparticles possess antibacterial characteristics. The cause of this phenomenon may be attributed to the well-recognized antibacterial properties of Silver. These attributes impede the proliferation of bacteria by disrupting their physiological processes and inducing their demise. The findings indicate that the addition of silver nanoparticles to dental fillings might potentially decrease the likelihood of bacterial infection and improve the overall safety of the fillings over an extended period of time. Furthermore, it has the ability to provide further safeguarding for teeth against dental caries and ailments linked to the proliferation of bacteria.

CONCLUSION

The conventional method used to evaluate microorganisms in dental filling samples, which incorporates the use of silver nanoparticles, has yielded significant insights into the effects of silver nanoparticles on bacterial proliferation. Through a systematic examination and analysis, we may deduce the following conclusions: The analysis of the reference sample indicated a notable prevalence of bacteria throughout testing in the absence of silver nanoparticles. This underscores the susceptibility of dental fillings to bacterial colonization in the absence of antimicrobial treatments, which gives rise to worries over the potential for infection or degradation. An analysis of materials containing silver nanoparticles shown a progressive decrease in bacterial populations at concentrations of 2%, 3%, 4%, and 5%. The decline in bacterial proliferation becomes more apparent as the ratio of silver nanoparticles rises. The observed pattern suggests that silver nanoparticles possess significant antibacterial characteristics, substantially inhibiting the proliferation of microorganisms. Analysis and Implications: The inverse relationship between silver nanoparticle concentrations and bacterial growth indicates the antibacterial properties of silver. Silver nanoparticles interfere with bacterial physiological functions, leading to a reduction in bacterial numbers. The results suggest that the use of silver nanoparticles into dental fillings may decrease the probability of bacterial infection and enhance the long-term safety and efficacy of dental restorations. The use of silver nanoparticles into dental fillings has significant promise for improving dental healthcare outcomes. By harnessing the antibacterial properties of Silver, dental fillings may provide enhanced protection against bacterial development, hence reducing the incidence of tooth caries and associated diseases. Further research and progress in this area have the potential to revolutionize dental materials and improve oral health for people worldwide.

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