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Silver Nanoparticles to Increase Antibacterial Efficiency in Bandages

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

A Survey of WHO showed that the wound infections rates are 5 - 34% in the world. It is necessary to treat the wounds properly as it will cause more infection inside the skin. Usage of normal bandages for the treatment of wounds or infections can heal the outer surface of the skin that too by a slow process. Many researchers started investigating the different healing properties of plant based bandages. Silver nanoparticles are known for their efficient antibacterial properties. It has gained greater attention in the biomedical industries. In this study, the nanoparticles are synthesized by using environment friendly green synthesis method. *Ceiba pentandra* aqueous leaf extract was used as reducing and capping agent for the silver nanoparticle synthesis. It was then evenly coated on a bamboo fabric material and then assessed for its antibacterial activity by using quantitative method. It is less hazardous as no toxic chemicals are involved. The Antibacterial activity of silver nanoparticles combined with the plant extract will exhibit efficient wound healing properties. The Bandage layer can further be designed to form a completely plant based product.

Keywords: Silver nanoparticles; plant based; bandages; antibacterial activity.

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1. INTRODUCTION

Popular perceptions of medicinal plant use and effectiveness play an important role in the disclosure of their therapeutic properties because they are often administered, even though their chemical constituents are not always fully understood [1]. With the advent and spread of microbial species resistant to multiple antibiotics, as well as a focus on lowering health-care costs, several researchers have attempted to create new effective antimicrobial reagents that are both sensitive and inexpensive. Such concerns and demands have caused a revival in the usage of Ag-based antiseptics, which are thought to have a wide range of action and a much lesser proclivity for inducing microbial resistance [2]. Antibacterial materials containing numerous natural and inorganic substances have been the subject of extensive research [3]. Antimicrobials play a critical role in reducing the global burden of infectious diseases [4]. A large number of medicinal plants have been identified as useful sources of natural antimicrobial compounds that may be effective in the treatment of difficult bacterial infections [5]. The importance of silver in biological applications has been known for over 2000 years. Silver has long been regarded as a disinfectant, and its nanoparticle forms allow it to be used in a variety of applications ranging from medicine to food [6]. Many antimicrobial applications use silver nanoparticles to improve their activity. Silver's antimicrobial activity is much superior to that of metals such as copper, mercury, lead, chromium, and tin [7]. Green synthesis is a process that uses plant extracts in place of expensive chemicals [8]. Plant extracts are easily available, non-toxic, and safe with various metabolites which aid in silver ion reduction [9]. Usage of parts of the whole plant in nanoparticle synthesis is exhilarating and underexplored [10]. The rate of synthesis can be faster by the usage of plant extracts compared to other microorganisms. One of the prospective options in the developing environment is the usage of silver nanoparticles as a coating in bandages and other medical equipment to reduce bacterial transfer. *Ceiba pentandra* exhibits many medicinal properties. Traditionally the leaf extracts are used in the treatment of malaria, diabetes, wound healing, asthma, gastrointestinal problems [11-13]. It shows inhibitory effects on many bacterial and fungal species. The leaves show high antimicrobial and analgesic properties. The phytochemical constituents present in the plant are alkaloids, flavonoids, glycosides, carbohydrates, tannins, saponins, and steroids [14]. In this study, the bamboo fabric was coated with the silver nanoparticles synthesized by using *Ceiba pentandra* aqueous leaf extracts and its antibacterial properties was investigated. The Coated bamboo fabric layer can be further designed into bandages by using natural plant based layers.

2. MATERIALS AND METHODS

2.1 Preparation of Sample

The extract of the leaf was prepared by combining finely chopped 20g of thoroughly washed leaves in a 500ml Erlenmeyer flask with 100 ml distilled water and stirred for 1 hour at 60°C. After cooling, the mixture was filtered through Whatman No. 1 filter paper.

2.2 Synthesis of Silver Nanoparticles

From the prepared leaf extract 5 ml of the extract was taken with 45 mM of AgNo3 in a conical flask and left for the bioreduction process to occur. It was kept at 30℃ in dark condition. The colour change which shows the reduction of AgNo3 into Silver nanoparticles was noted [15].

2.3 Antimicrobial Activity

2.3.1. Antibacterial coating of bamboo fabric

The fabric was coated by pad and dry cure method. For that, the Material to Liquor Ratio (MLR) was 1:40. The cross linking agent used for the coating was 6% citric acid according to the fabric weight. The fabric was dipped in the reduced silver nitrate solution of the leaf extract along with the cross linking agent for ten minutes. The fabric material is passed through the pneumatic padding mangle at a speed of 100 RPM with the confirmation of wet pickup at 70%. It was then shade dried and cured for 3 minutes at 140℃.

2.3.2 Antibacterial evaluation

Bacterial strains: The Bamboo material coated with the silver nanoparticles synthesized from aqueous leaf extracts of *Ceiba pentandra* was tested for its antibacterial activity against one gram positive bacterium (*Staphylococcus aureus*) and one gram negative bacterium (*Klebsiella pneumoniae*).

AATCC 100 Quantitative method: In individual petridishes, the determined number of cut and sterilized treated and untreated swatches are placed and equally distributed 1.0± 0.1 ml of diluted *S.aureus* and *K.pneumoniae* inoculum. Aseptically the swatches are all transferred to the screw cap bottle and are labelled with the time durations of 0 and 24hours.The 24 hour bottle is incubated at 37 ± 2℃ for 24hours. In 0 hour and 24 hour bottle, 100 ± 1ml of neutralising solution was added in the inoculated treated, inoculated untreated and un inoculated treated bottles. They are kept in shaker for 1min. 10^0, 10^{-1}, 10^{-2} and 10^{-3}serial dilutions are made using the neutralising solution and are plated. The plates are kept in the incubator at 37 ˚C ± 2 ˚C and incubated for 24 to 48 hours.

3. RESULTS AND DISCUSSION

3.1 Synthesis of Silver Nanoparticles

The plant extract showed a colour change which indicated the reduction of silver nitrate into silver nanoparticles. It was due to the bioreduction process.

3.2 Antibacterial Coating of Bamboo Fabric

The material taken for coating was bamboo due to its natural antibacterial properties. The fabric was coated by Pad and dry cure method. The usage of citric acid as cross linking agent was due to the binding properties. The fabric was dipped in the silver nanoparticle solution as in Fig. 1 and then passed through pneumatic paddig mangle to remove excess solution. The pressure was maintained at 1kg/cm2 in order to remove the excess of antibacterial solution with the confirmation of wet pickup at 70%. It was then shade dried.

3.2.1 Antibacterial activity

The antibacterial activity was done using AATCC 100 Quantitative method against *Klebsiella pneumoniae* (a gram negative bacterium) and *Staphylococcus aureus* (a gram positive bacterium). The 0 hr plates are examined, colonies are counted and recorded. Similarly, in the 24 hour plates 100 ± 1ml of neutralising solution is added and kept in shaker for 1 min, then incubated for 24 to 48hours. The 24 hour plates are examined for growth, the values are recorded and the percent reduction is calculated(R).

4. PERCENTAGE OF REDUCTION (R) = 99.99%

Bamboo material coated with the silver nanoparticles of *Ceiba pentandra* was effective against both the Gram positive and gram negative bacteria and showed the high percentage of reduction.

Fig. 1 a) Bamboo fabric dipped in silver nanoparticle solution

Fig. 1 b) Bamboo fabric passed through pneumatic padding mangle

Table 1. Growth count of *Klebsiella pneumoniae* in 0^{th} hour and 24^{th} hour

Validation	0^{th}HOUR			24^{th} HOUR		
Dilution	10^{-1}	10^{-2}	10^{-3}	10^{-1}	10^{-2}	10^{-3}
Count	195	22	3	0	0	0
Area %	93.774	88.627	50.740	33.357	35.776	36.473

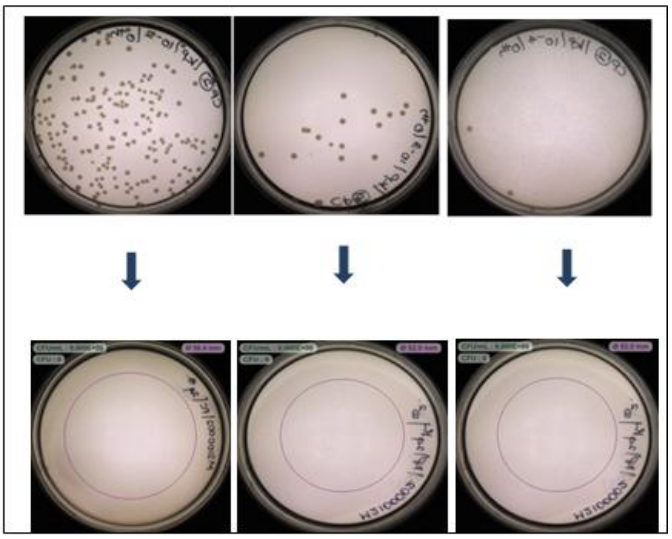

Fig. 2. *Klebsiella pneumoniae* growth count in 10^{-1}, 10^{-2}, 10^{-3} serial dilutions

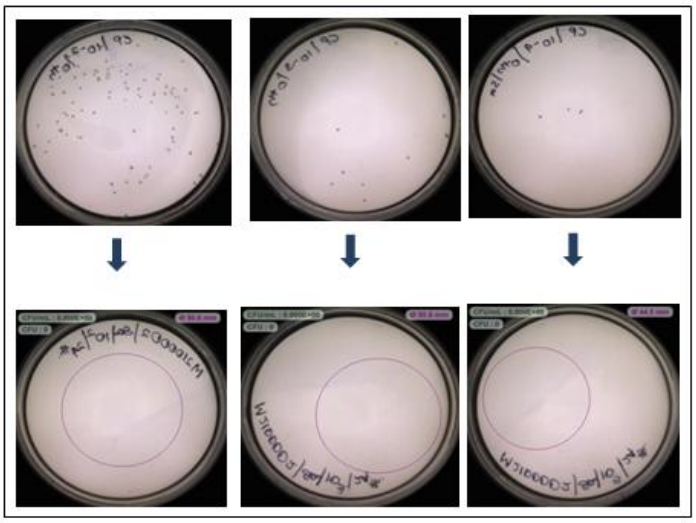

Fig. 3. *Staphylococcus aureus* growth count in 10^{-1}, 10^{-2}, 10^{-3} serial dilutions

Table 2. Growth count of *Staphylococcus aureus* in 0th hour and 24th hour

Validation	0th HOUR			24th HOUR		
Dilution	1e-1	1e-2	1e-3	1e-1	1e-2	1e-3
Count	106	14	2	0	0	0
Area %	91.550	92.288	34.027	31.818	32.818	23.350

5. CONCLUSION

This is a new approach for the production of biological bandages using the synthesized silver nanoparticles from the aqueous leaf extracts of an antimicrobial activity rich medicinal plant *Ceiba pentandra*, using the environmentally friendly method without the usage of chemicals. The Bamboo fabric layer coated with the silver nanoparticles can be designed with many chemical free and plant based layers. It will increase the wound healing properties and acts directly over the bacteria present. This can be further studied for the analysis of the bio-bandages and their active response over human infections or wounds.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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