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Synthesis of Silver Nanoparticles Impregnated Soap and its Study on Antibacterial Activity Using Green Principles

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ABSTRACT

The development of science and technology has nurtured the merging of green chemistry with green engineering and nanotechnology. Green nanotechnology has provided many breakthroughs in creating quality health and environment. In this study we report the synthesis of soap impregnated with silver nanoparticles using green principles. Green methodology was adopted to synthesize AgNPs to minimize the negative impacts of synthetic procedures and to develop environmentally benign procedures for the synthesis of metallic nanoparticles. We herein report Coleus Vettiveroids aqueous leaf extract mediated green synthesis of silver nanoparticles. The synthesized silver nanoparticles were characterized by UV-Vis Spectroscopy, Fluorescence Spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM), and Transmission Electron Microscopy (TEM). As a part of our continuous study, the synthesized silver nanoparticles (AgNPs) were impregnated in soap prepared by the saponification of coconut oil. It was further characterised by UV-Vis Spectroscopy, IR spectroscopy, and Scanning Electron Microscopy (SEM). The soap impregnated with silver nanoparticles (AgNPs) showed antibacterial activities against both gram positive and gram-negative bacteria. The study revealed the efficacy of synthesis of silver nanoparticles (AgNPs) using green principles and its potential application in health and environment

Keywords: Green synthesis; Silver nanoparticles; Coleus Vettiveroids; Soap impregnated with silver nanoparticles.

I. INTRODUCTION

Nanotechnology is one of the leading scientific fields today since it combines knowledge from the fields of Physics, Chemistry, Biology, Medicine, Informatics, and Engineering [1]. Novel nano biomaterials and nanodevices are fabricated and controlled by nanotechnology tools and techniques. In recent years, the advancement of metallic nanoparticles in an eco-friendly manner using plant materials has captured considerable attraction [2]. The biogenic reduction of metal ions to the base metal is quick, can be carried out readily at room temperature, can be scaled up easily, and the method is eco-friendly [3]. These biosynthesized metallic nanoparticles have a wide range of biological applications.

Biosynthesis of nanoparticles is an emerging recent addition to the large repertoire of nanoparticles synthesis methods and has entered a commercial exploration period. The antibacterial properties of the biosynthesized silver nanoparticles when incorporated on textile fabric were investigated [4]. The silver nanoparticles were also used for impregnation of polymeric medical devices to increase their antibacterial activity. Silver impregnated medical devices like surgical masks and implantable devices showed significant antimicrobial efficiency [5]. It is well known that silver binds to the bacterial cell wall and cell membrane and inhibits the respiration process [6].

Current applications for silver nanoparticle impregnat ed materials include:Toys, Baby pacifiers, Clothing, F ood storage containers, Face masks, HEPA filters and Laundry detergents. So the present study reports Synthesis of silver nanoparticles using ***coleus vettiberoids*** leaf extract which is an endemic species and its antibacterial activity on silver impregnated soap**.** The silver ions are bioactive and have broad spectrum of antimicrobial properties against a wide range of bacteria [7].

1.1. METHODS AND MATERIAL

Materials

Chemicals used were purchased from Fisher Scientific and deionized water was used throughout the experiments.

Instrumentation Technique

UV-Visible spectral analysis was done by using Double beam UV-Visible spectrophotometer (specrtoscan UV-2600), with the revolution of 1nm between 300-700 nm. FT-IR spectra were recorded by using Bruker FTIR spectrophotometer in the range of 500-4000 cm^{-1}. **Synthesis of silver nanoparticles**

For synthesis of silver nanoparticles from aqueous leaf extract of ***C.vettiveroids*** 10 ml of aqueous plant extract was added to 90 ml of 2mM aqueous silver nitrate solution and was incubated.

Preparation of soap

100mL of water is mixed 25g of NaOH with constant stirring till all the NaOH dissolves completely to form a colourless solution. It is allowed to cool for 24 hours at room temperature. To this solution 100mL of warm coconut oil is added with constant stirring. The mixture becomes viscous, thick and whitish in colour. This thick viscous paste is soap. It is salted out by adding common salt .The soap precipitates and floats up the watery layer of salt solution. It is filtered and poured into a mould, cooled and dried. This is the soap base.

Preparation of silver impregnated soap

4.80g of soap base was weighed accurately and taken in a beaker. 0.20g of silver nanoparticles were added, mixed well and warmed when a slurry was formed. It was stirred well and poured into a mould, allowed to cool and dried.

Antibacterial activity

The skin pathogenic bacteria namely *Staphylococcus Aureus* (MTCC 96) and *Staphylococcus Epidermidis* (MTCC 435) were used for *in vitro* antimicrobial activity. These selected type strains were obtained from Microbial Type Culture Collection (MTCC), Chandigarh, Punjab, India [8].

II. RESULTS AND DISCUSSION

Characterization of synthesized silver nanoparticles

Visual formation of silver nanoparticles was observed by change of colour from yellow to brown and finally to colloidal brown indicating the formation of silver nanoparticles while adding leaf extract with silver ion solution due to the excitation of free electron in the nanoparticles .The reduction of silver ion (Ag+) to metallic silver nanoparticles (Ag) was spectrometrically identified by double beam UV-visible spectrophotometer. The maximum absorption peak of synthesized AgNPS was observed at 410 nm (Figure 1). The biosynthesis of the silver nanoparticles with average particle size of 10-17 nm has been confirmed by UV-Vis and IR spectroscopy , SEM and TEM images.

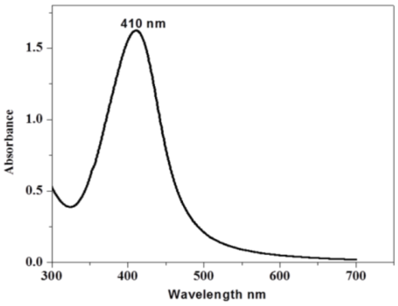


Figure 1. UV-Visible absorbance and IR spectrum of synthesized AgNPs from aqueous leaf extract of Coleus vettiveroids

The intense broad band at 3270 cm^{-1} is due to the N-H and O-H stretching mode in the linkages of proteins which could be attributed to amines and amides of proteins found in ***Coleus Vettiveroids*** aqueous leaf extract.The medium intense band at 1640cm^{-1} arises from the C=O stretching mode found in flavonoids, alkaloids, carbohydrates and amide group which is commonly found in the protein , indicating the presence of these natural products acting as capping agent for AgNPs which increases the stability of nanoparticle (Figure 2) .

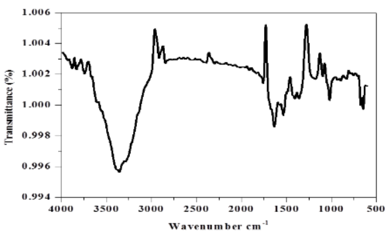
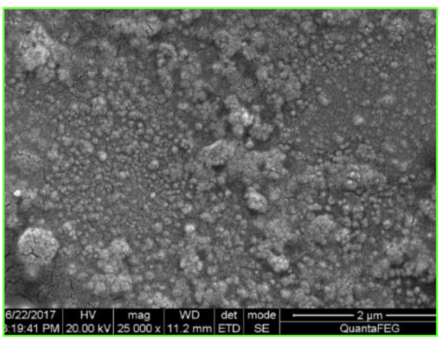
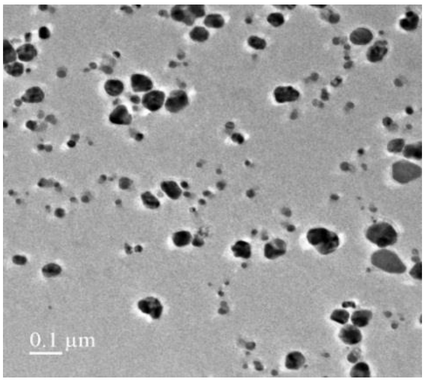


Figure 2. FTIR spectrum of synthesized AgNPs.

SEM and TEM analysis showed indicated that the particles were spherical and size ranging between 10-17 nm.(Figure 3)





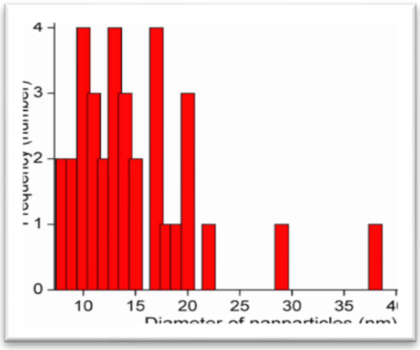


Figure 3. SEM and TEM images of synthesized silver naoparticles from ***Coleus vettiveroids*** aqueous leaf extract

3.2. UV- visible spectra of silver impregnated soap
UV-visible absorbance spectra of soap alone and soap impregnated with silver nanoparticles are also shown in fig 4a and b. Solution of soap impregnated with AgNPs absorb in the ultraviolet region of 380-420 nm. Therefore, it can be used not only as antimicrobial agents but also as protectors from UV-exposure [9].

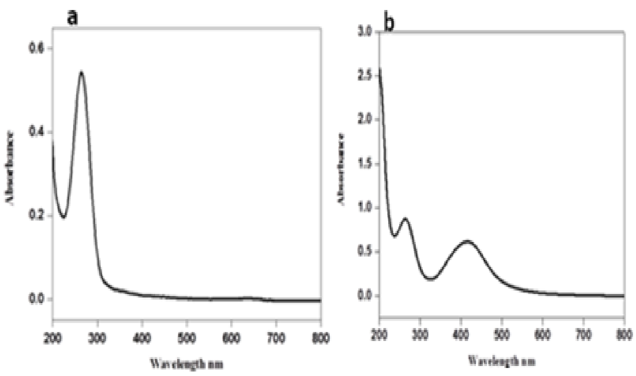


Figure 4. UV-Visible absorbance spectra of prepared (a) soap (b) soap impregnated with AgNPs.

FTIR Analysis

FTIR analysis was carried out for silver nanoparticles impregnated soap (fig 5). Peak at 3330.40 cm^{-1} corresponds to phenolic group of polyphenols and glycerol. The prominent peak observed at 1720 cm^{-1} is due to stretching absorption of aldehyde (C=O). Coconut oil should exhibit a low rate of oxidation due to its low content of unsaturated fatty acids. Two alkane peaks is attributed to bending absorption of Methylene (CH_2) and methyl (CH_3) groups at 1380 and 1275 cm^{-1} respectively.

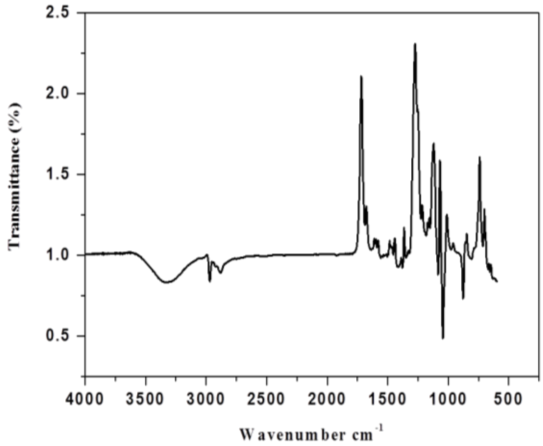
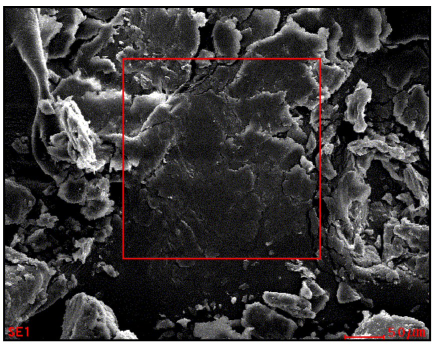


Figure 5. FTIR spectrum of silver nanoparticles impregnated soap

SEM Analysis

SEM images of soap impregnated with silver nanoparticles exhibited spherically agglomerated particles due to the presence of soap (figure 6).



Element	*Wt%*	*At%*
CK	79.08	85.35
OK	13.14	10.65
NaK	06.28	03.54
ClK	01.14	00.42
AgL	00.36	00.04
Matrix	Correction	ZAF

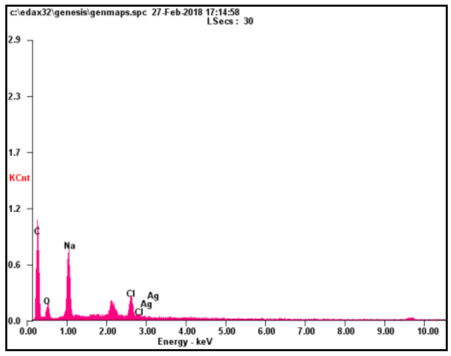


Figure 6. SEM images of silver nanoparticles impregnated soap

Antibacterial activity of soap impregnated with AgNPs:

The bactericidal properties of soap impregnated with AgNPs are confirmed in studies against gram positive (*Staphylococcus Aureus*) and gram negative (*Staphylococcus epidermidis)* bacterial strain (Figure 7). For silver nanoparticles impregnated soap, the highest concentration of 100 µg/ml showed activity ranged between 8mm for *Staphylococcus epidermidis* and 9 mm ZOI for *Staphylococcus Aureus* (Table 1). There was no antibacterial activity found for soap alone. Aritra Saha et. al, have also reported that silver nanoparticle impregnated biomedical fiber showed efficient antimicrobial activity [10]. It is reported that Silver nanoparticles have the advantage of high anti-microbial activity even at low concentrations [11-12].

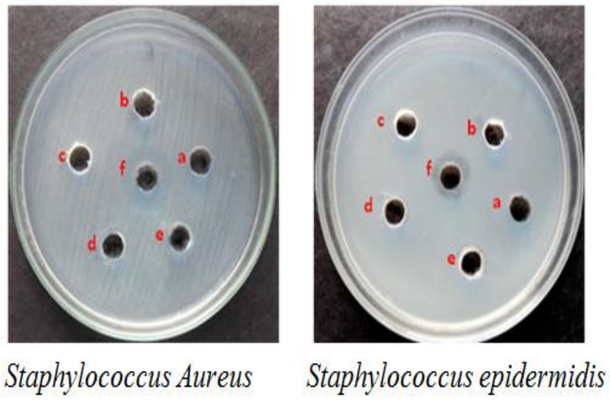


Figure 7. The antibacterial activity determination by well diffusion methods (a: 0µg/well; b: 25µg/well; c: 50µg/well; d: 75µg/well; e: 100µg/well; f: 30µg/well (Azithromycin)

III. CONCLUSION

We herein report the green synthesis of stable silver nanoparticles as small as 10nm using endemic plant species ***Coleus vettiveroids*** aqueous leaf extract. Synthesis is found to be efficient in terms of reaction time as well as stability of synthesized nanoparticles without any external stabilizers and reducing agents. Further the AgNPs were impregnated in soap and characterized using UV, IR and SEM studies. Soap impregnated with AgNPs, were tested for antibacterial activity and the results are promising. The study revealed the efficacy of synthesis of silver nanoparticles (AgNPs) using green principles and its potential application in health and environment.

Conflict of Interests:

The author declares that there is no conflict of interests regarding the publication of this paper.

IV. ACKNOWLEDGEMENT

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Table 1. Antibacterial activity of soap impregnated with AgNPs

Concentrations(µg)	Zone of inhibition(mm) Staphylococcus .Aureus	Zone of inhibition (mm) *Staphylococcus epidermidis*
25	03	02
50	06	05
75	08	07
100	09	08

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