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Sunlight mediated synthesis of silver nanoparticles by a novel actinobacterium (*Sinomonas mesophila* MPKL 26) and its antimicrobial activity against multi drug resistant *Staphylococcus aureus*

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ABSTRACT

Synthesis of silver nanoparticles using microorganism are many, but there are only scanty reports using actinobacteria. In the present study, the actinobacterium of the genus *Sinomonas* was reported to synthesis silver nanoparticles for the first time. A photo-irradiation based method was developed for the synthesis of silver nanoparticles, which includes two day old cultural supernatant of novel species *Sinomonas mesophila* MPKL 26 and silver nitrate solution, exposed to sunlight. The preliminary synthesis of silver nanoparticles was noted by the color change of the solution from colorless to brown; the synthesis was further confirmed using UV–visible spectroscopy which shows a peak between 400 and 450 nm. Spherical shape silver nanoparticles of size range 4–50 nm were synthesized, which were characterized using transmission electron microscopy. The Fourier transform infrared spectroscopy result indicates that, the metabolite produced by the novel species *S. mesophila* MPKL 26 was the probable reducing/capping agent involved in the synthesis of silver nanoparticles. The synthesized silver nanoparticles maintained consistent shape with respect to different time periods. The synthesized silver nanoparticles were evaluated for the antimicrobial activity against multi drug resistant *Staphylococcus aureus* which show good antimicrobial activity. The method developed for synthesis is easy, requires less time (20 min) and produces spherical shape nanoparticles of size as small as 4 nm, having good antimicrobial activity. Hence, our study enlarges the scope of actinobacteria for the rapid biosynthesis of silver nanoparticles and can be used in formulating remedies for multi drug resistant *S. aureus*.

1. Introduction

Nanoparticles are the bridge that fills the gap between bulk materials and atomic or molecular structures. In recent years, the use of microorganisms for nanoparticles synthesis (especially silver nanoparticles) is rapidly gaining importance due to their ease of synthesis, rendering the toxic chemicals and quite eco-friendly processes. The potential use of microorganisms for the synthesis of silver nanoparticles ranges from simple prokaryote to eukaryotic cell [1,2]. Bacteria like *Escherichia coli*, *Enterobacter cloacae* and *Klebsiella pneumonia* [3]; fungi like *Fusarium oxysporum*, *Fusarium semitectum*, *F. acuminatum*, *Fusarium solani*, *Cladosporium cladosporioides* and *Trichoderma asperellum* can synthesize silver nanoparticles with wide applications [4]. Though several reports on synthesis of silver nanoparticles using bacteria and fungi were reported, however, there are only few reports on the synthesis of nanoparticles using actinobacteria. Recently few actinobacteria were explored for the synthesis of silver nanoparticles [5,6] but these processes were rather slow.

In the past few years, we developed photo-irradiated actinobacteria mediated synthesis of silver nanoparticles, which requires less time [7,8] but in these studies we restricted our self to the genus *Streptomyces*. In order to enlarge the scope of actinobateria in the rapid biosynthesis of

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Table 1
Antibiotic susceptibility test of *S. aureus*.

Sl. No.	Antibiotic	Results
1.	Penicillin	Resistant
2.	Methicillin	Resistant
3.	Oxacillin	Resistant
4.	Gentamycin	Resistant
5.	Vancomycin	Susceptible

silver nanoparticles, we explore a novel species *Sinomonas mesophila* (*S. mesophila*) MPKL 26 for the synthesis of silver nanoparticles using sunlight.

Sinomonas is a Gram positive, non-motile actinobacteria. The peculiar character of this genus is the cells are bent rod in shape. Since the discovery of the genus *Sinomonas* [9,10], this is the first report on the synthesis of silver nanoparticles using sunlight. To further strengthen our novel biological synthesis, we performed the application study. The synthesized silver nanoparticles were accessed for antimicrobial studies against multi drug resistant (MDR) *Staphylococcus aureus* (*S. aureus*).

2. Materials and Methods

2.1. Isolation of and Identification of Novel Species S. mesophila MPKL 26

The novel strain MPKL 26 which belong to the genus *Sinomonas* was identified based on phenotypic, chemotaxonomic and molecular characteristics which was mentioned elsewhere [10].

2.2. Isolation of Multi Drug Resistant S. aureus

The identification of *S. aureus* was done using our earlier method [7]. Among the isolated *S. aureus*, multi drug resistant (MDR) *S. aureus* was identified by antibiotic susceptibility test (Table 1) as per the Clinical and Laboratory Standards Institute (CLSI-2012) [11].

2.3. Growth Condition and Synthesis of Silver Nanoparticles by S. mesophila MPKL 26

S. mesophila MPKL 26 was grown in 250 ml Erlenmeyer flask containing 100 ml of International *Streptomyces* project (ISP) 2 medium. The flask was incubated for 2 days at 30 °C and then the medium was centrifuged at 10,000 rpm for 10 min. The supernatant obtained was used for the synthesis of silver nanoparticles as per our earlier standard protocol, which includes the supernatant (1 ml) and treated with different volumes of silver nitrate solution (10^{-3} M) and exposed to sunlight for a time period of 20 min [7]. The same sample was kept in the dark to check whether silver nanoparticles synthesis occurs in the absence of sunlight.

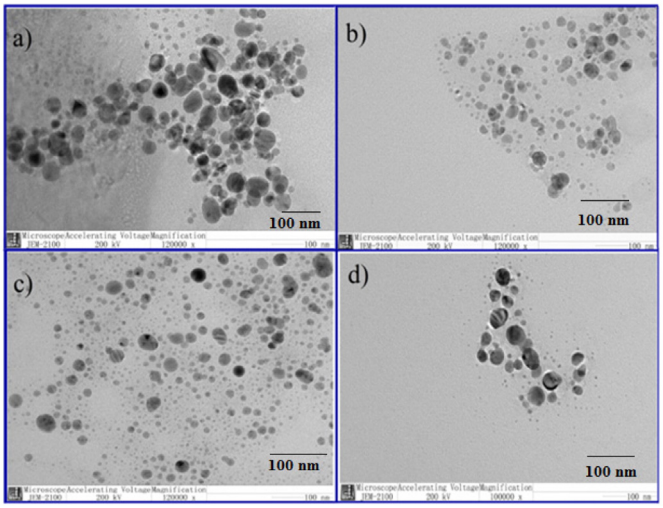

Fig. 2. TEM images of silver nanoparticles a) at 5 min, b) at 10 min, c) at 15 min and d) at 20 min.

The synthesis of silver nanoparticles was confirmed using UV–visible spectroscopy and transmission electron microscopy (TEM) analysis. Further, the probable reducing agent for synthesis of silver nanoparticles was known by using Fourier transform infrared spectroscopy (FTIR) analysis.

The UV–visible spectroscopy was conducted on a Systronics 2200 double beam UV–visible spectrophotometer. The TEM analysis was carried on a JEOL JEM-2100 Transmission Electron Microscope. FTIR analysis of the MPKL 26 strain supernatant and synthesized nanoparticles was carried out on a Thermo Nicolet, Avatar 370 instrument.

2.4. Antimicrobial Activities of Silver Nanoparticles Against MDR S. aureus

To evaluate the antimicrobial activity of silver nanoparticles, MDR *S. aureus* maintained at 0.5 McFarland were spread with the aid of sterile cotton swabs on Mueller Hinton agar (MHA). A 6 mm diameter well was punched carefully with the help of a cork borer then, the well was loaded with 100 μL of silver nanoparticles (concentration 1.56 g/1000 ml). The plate was incubated at 37 °C for 24 h. Antibacterial activity was determined by measuring the zone of inhibition.

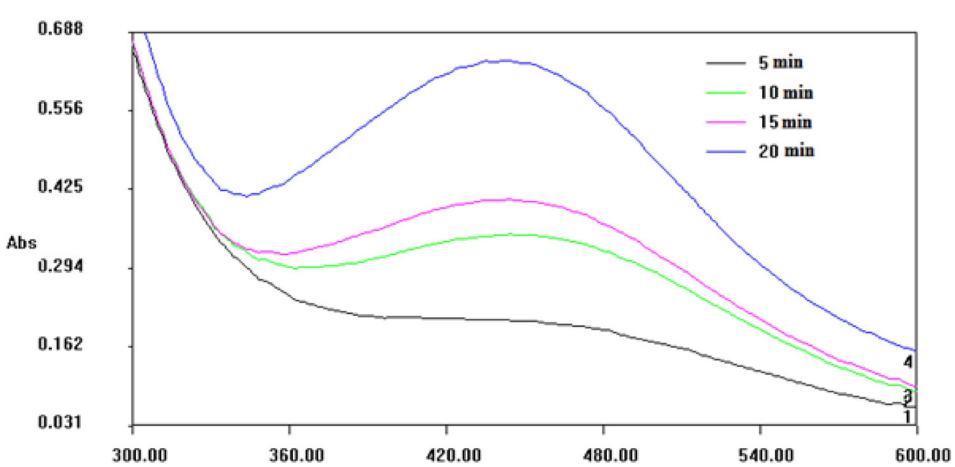

Fig. 1. UV–visible spectroscopy of silver nanoparticles.