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Plant-mediated synthesis of silver nanoparticles using fruit extract of *Cleome viscosa* L.: Assessment of their antibacterial and anticancer activity

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Abstract

Green synthesis of silver nanoparticles was successfully done using *Cleome viscosa* plant extract, simple, rapid, eco-friendly and a cheaper method. In this study, we used *C. viscosa* extract for synthesizing silver nanoparticles which reduces silver nitrate into silver ions. The obtained AgNPs were characterized by UV, FTIR, XRD, FESEM-EDAX and TEM analysis. They were also analyzed for their biological activities. The presence of biosynthesized AgNPs (410–430 nm) was confirmed by UV–visible spectroscopy and also crystal nature of AgNPs confirmed through XRD analysis; FT-IR spectrum was used to confirm the presence of different functional groups in the biomolecules which act as a capping agent for the nanoparticles. The morphology of AgNPs was analyzed using SEM and the presence of silver was confirmed through elemental analysis. The size of the nanoparticles was in the range of 20–50 nm determined by TEM. The green synthesized AgNPs exhibited a good antibacterial activity against both Gram negative and Gram positive bacteria. Furthermore, the green synthesized AgNPs showed reliable anticancer activity on the lung (A549) and ovarian (PA1) cancer cell lines.

Keywords: *C. viscosa*; XRD; FESEM; TEM; Anticancer

1. Introduction

Green nanotechnology is an interdisciplinary field for the production of functional nanoparticles of gold, silver, zinc, etc, [1,2]. Silver nanoparticles (AgNPs) possessed many noteworthy biological roles in the fields like therapeutics (antimicrobial, anticancer, anti-parasitic, antidiabetic and antioxidant activities) [3–7], bio-molecular detection and diagnostics, drug delivery, food production, agriculture and for the treatment of waste [8–12]. Green synthesis of AgNPs was attempted using plant extracts was taken into account in this study. *Cleome viscosa* L. (family: Capparidaceae) is a common weed which is present in the tropical regions of the World [13]. It is commonly called as tick-weed, wild mustard and whole plants are widely used in the traditional systems of medicine [14]. Fresh leaves of this plant are used for the treatment of jaundice in the Indian folklore medicines [15].

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The *C. viscosa* fruit extract containing rich amount of enzymic and non enzymic antioxidant molecules such as catalase, peroxidase, Polyphenol oxidase, superoxide dismutase, glutathione-S-transferase, ascorbic acid, α-tocopherol, reduced glutathione and flavonoids [42]. Those are played the key role for the synthesis silver nanoparticle by the way of reducing and capping agent.

Bioactive secondary metabolites such as phenols, flavonoids, alkaloids and terpenoids are present in medicinal plants. These are used for curing many diseases including disorders and infectious diseases [16]. Synthesis of nanoparticles from plants has been gaining importance in recent years due to their solvent free nature and less toxicity. Besides, their production is faster, which is also cost-effective [17,18]. Reports have emerged that the biosynthesis AgNPs can also be synthesized from microorganisms such as bacteria, yeast, fungus [19–26]. These NPS showed potential biological applications in various fields [27–29]. Recently, metal nanoparticles were applied in shampoos, soaps, detergents, cosmetics, toothpaste and medical and pharmaceutical products. Hence they are directly encountered to human systems [30,31].

To the best of our knowledge and literature survey, *C. viscosa* has not been used for the synthesis of silver nanoparticles. In this study, an attempt was made to the green synthesis of AgNPs from *C. viscosa* and was characterized. The same was also used to assess their effect on biological systems.

2. Materials and methods

2.1. Materials

AgNPs were synthesized from *C. viscosa* fruit extract, Silver nitrate ($AgNO_3$) was purchased from Sigma–Aldrich, Nutrient agar, Muller Hilton Agar were procured from HiMedia, India and Dimethyl Sulfoxide (DMSO) from SD Fine-Chem Limited, India.

2.2. Preparation of aqueous fruit extract of C. viscosa

Fresh and healthy fruits of *C. viscosa* were selected for the biosynthesis of AgNPs because of its cost effectiveness, ease of availability and medicinal properties. *C. viscosa* was collected from University of Madras, Guindy campus and it was cleaned using tap water followed by double distilled water. Around 10 g of washed fruits were boiled with 100 mL distilled water for 30 min at 60 °C and the extract was obtained after filtration through Whatman No. 1 filter paper and was used for further experiments [32].

2.3. Synthesis of AgNPs aqueous fruit extracts using C. viscosa

The obtained fruit extract (10 mL) was incubated with 1 mM of silver nitrate solution (100 mL) in the dark condition for 24 h. The synthesis of silver nanoparticles was done at room temperature (25 °C ± 2 °C). A change in the color of the solution from light green to brown indicated the synthesis of AgNPs.

2.4. Characterization of AgNPs

The green synthesized AgNPs were characterized by UV–visible spectrophotometer at (HITACHI, U-2800) in the range of 200–600 nm. The X-ray diffraction (XRD) was used to investigate the crystalline structure of AgNPs. XRD was recorded in the 2θ range (30–80) using XRD6000, (Shimadzu). The presence of functional groups in *C. viscosa* fruit extract synthesized AgNPs were identified by Shimadzu 8400 FTIR Spectrophotometer (Perkin Elmer Spectrum) using KBr pellet technique at the range of 4000–400 cm^{-1}. The morphology of AgNPs was examined using FE-SEM, and the presence of silver was confirmed by EDAX. Furthermore, the AgNPs were analyzed through TEM determining their size and shape. The average size and stability of the *C. viscosa* mediated synthesized silver nanoparticles were determined by dynamic light scattering (DLS) technique and the zeta potential by using Zeta size analyzer (Malvern instruments Ltd., UK). For this analysis, the samples were filtered (0.2 μm) and the clear nanoparticles solution was used and the measurement was taken at the respective range.

2.5. Antibacterial activity

The antibacterial activity of AgNPs was determined by well diffusion method against the *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli* and *Klebsiella pneumoniae* on the Muller-Hinton agar plates. The incubated bacterial culture (10^7/mL) was swabbed uniformly using a sterile cotton swab. Various concentration of (10–40 μg/mL) silver nanoparticles was poured into each well on all the plates after which they were incubated at 37 °C for 18 h. After incubation, the clear zone appeared and it was measured as a zone of inhibition [33]. Standard antibiotic tetracycline was used as a positive control.

2.6. Anticancer activity

In vitro anticancer activity of green synthesized AgNPs was evaluated against human cancer cell lines

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