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Marine sponge extract assisted biosynthesis of silver nanoparticles

D. Inbakandan a,b,*, G. Sivaleela c, D. Magesh Peter d, R. Kiurbagaran d, R. Venkatesan d, S. Ajmal Khan b

a Centre for Ocean Research, Sathyabama University, Rajiv Gandhi Salai (OMR), Chennai 600119, India
b Centre of Advanced Study in Marine Biology, Annamalai University, Parangipettai 608502, Tamil Nadu, India
c Marine Biology Regional Centre (ZSI), Chennai 600028, India
d National Institute of Ocean Technology, Pallikaranai, Chennai 600036, India

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A B S T R A C T

Biotic factors mediated biosynthesis of nanoparticles is considered as an eco friendly and green technological approach compared to chemical and physical methods. This work reports the biosynthesis of silver nanoparticles using the extract of marine sponge, Acanthella elongata. Water-soluble organics present in marine sponge extract were mainly responsible for the reduction of silver ions. UV–visible spectrum of the aqueous medium containing silver nanoparticles showed plasmon resonance peak at around 426 nm. The X-ray diffraction pattern (XRD) of 2θ = 38.1°, 44.3°, 64.5° and 77.4°, confirmed the crystalline nature of the silver nanoparticles. Transmission electron microscopy (TEM) analysis of silver nanoparticles indicated the sizes, ranging from 15 nm to 34 nm in diameter and a spherical shaped polydispersal of the particles. Through Fourier transform infrared spectroscopy (FT-IR) analysis the possible biochemical agent present in the marine sponge extract was identified as amines which were the cause for the bioreduction of silver salt to silver nanoparticles.

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1. Introduction

Over the past years, nanoparticles have been the theme of colossal concern due to their prospective applications in industrial, biomedical and electronic applications. Presently there is a budding need to build up environmentally compassionate nanoparticle synthesis processes that do not use noxious compounds in the synthesis procedures. Eco-friendly green synthetic procedures include mixed-valence polyoxometalates [1], polysaccharides [2], tannins [3], irradiation [4] and biological methods [5]. In the biological method, extracts from living organisms may act both as reducing and capping agents in synthesis of nanoparticles. The reduction of metal ions by combinations of biomolecules found in these extracts such as enzymes/proteins, amino acids, polysaccharides, and vitamins is environmentally benign, yet chemically complex [6]. Thus, synthesis of silver nanoparticles by chemical methods leads to the presence of some toxic chemical species adsorbed on the surface that may have adverse effects in biological applications. Therefore synthesis of nanoparticles using biological entities can potentially eliminate this problem by making the nanoparticles more biocompatible. Biosynthesis of nanoparticles using bacteria, actinomycetes, yeast, fungi and plants were reported and reviewed [7–9]. Our previous attempt on marine resources to find secondary metabolites to get a marine natural antifoulants [10] gave an idea to explore the Poriferans extract for the bioproduction of metal colloids. Interestingly while attempting extraction with marine sponge Acanthella elongata with water it reduced the gold precursor resulting in spherical shaped polydispersed gold nanoparticles [11]. On this background, considering the chemical richness of marine sponges [12] as a valuable key, we have explored and synthesized stable silver nanoparticles by the reduction of aqueous silver nitrate using extract of marine sponge, A. elongata. Interestingly, this is the first report in synthesis of stable silver nanoparticles using marine sponge A. elongata.

2. Experimental section

Marine sponges were collected from intertidal and subtidal regions (1–5 m deep, using SCUBA) of Gulf of Mannar (8° 58′ 25″’N 78° 42′ 52″’E), South Tamilnadu, India. Samples were collected in bulk depending on the abundance of individual organisms and washed with freshwater to remove adhering debris and associated biota. Collected samples were stored in a refrigerated box and transferred to the lab. Further the sponge samples are labeled properly and stored at −70 °C. The taxonomic identification of the organisms was done using spicules separated using nitric acid digestion following standard identification keys [13,14].
Five grams of sponge was weighed and ground in 30 mL of water using sterile pestle and mortar. After a systematic grinding the crude extract was filtered using Whatman no. 1 (42 μm) filter paper and the residue was again ground with 20 mL of water and filtered. From the filtrate, 10 mL was taken and added to 100 mL of 10⁻³ M AgNO₃ aqueous solution and kept at 45°C. The 95% of the bioreduction of AgNO₃ ions occurred within 2 h of continuous stirring. A color change to yellowish brown of the medium was noted by visual observation confirming the bioreduction. Aliquot of the reaction solution was taken in a quartz cuvette and absorptions were measured using a UV-1601 Shimadzu spectrophotometer operated at a resolution of 1 nm, and the absorption maxima was scanned at the wavelength of 300–700 nm.

Samples for high-resolution transmission electron microscopic (HR-TEM) analysis were prepared by drop coating Ag nanoparticles solutions onto carbon coated copper TEM grids. The films on the TEM grids were allowed to stand for 2 min following which the extra solution was removed using a blotting paper and the grid was allowed to dry, prior to the measurement. HR-TEM measurements were performed on a JEOL 3010 instrument operated at an accelerating voltage of 300 kV. X-ray diffraction (XRD) measurement of the Ag nanoparticles was carried out on films of the respective solutions drop coated onto glass substrates on an Enraf Nonius CAD4-MV31 single crystal X-ray diffractometer instrument operating at a voltage of 50 kV and a current of 40 mA with CuKα radiations. For FTIR measurements, both the sponge extract and the reduced colloidal solution were analyzed on a Perkin Elmer FT-IR instrument in the diffused reflectance mode at a resolution of 4.0 cm⁻¹. In order to obtain good signal/noise ratio, 512 scans were recorded.

### 3. Results and discussion

Though biosynthesis of nanosilver was reported recently in *Morganella* spp. [15], *Eichornia crassipes* [16], *Syzygium aromaticum* [17], *Annona squamosa* [18], *Dioscorea bulbifera* [19], *Arbutus unedo* [20], *Streptomyces* spp. [21] and *Rhodococcus* spp. [22] etc., we are proud to report for the first time of biosynthesis of silver nanoparticles using the marine sponge *A. elongata*.

After 2 h of the reaction, it was observed that the color of the solution in flask was turned to yellowish brown. It confirmed the formation of silver nanoparticles and the color change was due to excitation of surface plasmon vibrations in the metal nanoparticles. This important observation indicates the reduction of the Ag⁺ ions and the biosynthesis of silver nanoparticles. A band observed in UV–visible spectrum (Fig. 1) corresponding to the surface plasmon resonance occurs at 426 nm and clearly indicates the formation of silver nanoparticles in solution as the exact position of absorbance depends on a number of factors such as the dielectric constant of the medium, size of the particle, etc. The silver nanoparticles that got reduced with the help of the *A. elongata* sponge extract had dimensions small enough to be electron transparent and imaged by TEM as polydispersed spherical nanoparticles with variable diameter ranging from 15 nm to 34 nm (Fig. 2). The histogram obtained using the enlarged TEM illustration revealed that almost 20% of the particles were 24 nm in diameter.

The XRD patterns of 2θ = 38.1°, 44.3°, 64.5° and 77.4° of the biosynthesized silver nanoparticles are in agreement with the JCPDS (No. 65-2871) of bulk silver, which further proves the formation of crystalline silver. The crystalline peaks were identified as silver nanoparticles according to the PCPDFWIN software,

![Fig. 1. UV–visible spectrum of nanoparticles at the end of the reaction with the extract of marine sponge, *Acanthella elongata* and aqueous solution of 10⁻³ M silver nitrate solution. (426 nm).](image1)

![Fig. 2. HR-TEM images of biosynthesized silver nanoparticles: (a) 50 nm scale; (b) 5 nm scale;and (c) selected area diffraction pattern.](image2)
version 2.1. The intense peaks of reflected radiation (known as Bragg peaks) were produced at (111), (200), (220) and (311) planes by XRD analysis are assigned to the diffraction lines of the face-center-cubic (fcc) silver, respectively (Fig. 3). The particle size of the AgNPs formed were calculated using the Debye–Scherrer equation which was around 24 nm, were good in agreement with TEM results also.

FTIR spectrum of the sponge extract of A. elongata shows peaks at 3255, 2039, 1628, 1006 and 662 cm\(^{-1}\), where as the FTIR spectrum of silver nanoparticles biosynthesized by sponge extract of A. elongata shows peaks at 3345, 2078, 1634, 1031 and 627 cm\(^{-1}\) (Fig. 4). A band shift from 3255 cm\(^{-1}\) corresponding to O–H broad stretching of high concentration of alcohols to 3345 cm\(^{-1}\) corresponding to N–H stretching vibration of primary amines, or a shift from the strong band at 1006 cm\(^{-1}\) corresponding to C–X stretching of fluoroalkanes to strong band at 1031 cm\(^{-1}\) corresponding to C–N stretching and overlapping of aliphatic amines were the cause for the bioreduction of silver salt to silver nanoparticles.

4. Conclusion

In conclusion, the marine sponge reduction of silver precursor by A. elongata yielded uniform silver nanoparticles. The present investigation indicates extracellular synthesis of stable silver nanoparticles by biotransformation using the extract of marine sponge. This simple procedure for the biosynthesis of silver nanoparticles has several advantages such as cost-effectiveness, compatibility for biomedical and pharmaceutical applications as well as for large scale commercial production.

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