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Original Article

Ultrastructures of silver nanoparticles biosynthesized using endophytic fungi

Lamabam Sophiya Devi, S.R. Joshi *

Microbiology Laboratory, Department of Biotechnology & Bioinformatics, North-Eastern Hill University, Shillong 793 022, Meghalaya, India

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ABSTRACT

Three endophytic fungi *Aspergillus tamarii* PFL2, *Aspergillus niger* PFR6 and *Penicllium ochrochloron* PFR8 isolated from an ethno-medicinal plant *Potentilla fulgens* L. were used for the biosynthesis of silver nanoparticles. Scanning and transmission electron microscopic analysis were performed to study the structural morphology of the biosynthesized silver nanoparticles. The electron microscopy study revealed the formation of spherical nano-sized silver particles with different sizes. The nanoparticles synthesized using the fungus *A. tamarii* PFL2 was found to have the smallest average particle size (3.5 ± 3 nm) as compared to the nanoparticles biosynthesized using other two fungi *A. niger* PFR6 and *P. ochrochloron* PFR8 which produced average particle sizes of 8.7 ± 6 nm and 7.7 ± 4.3 nm, respectively. The energy dispersive X-ray spectroscopy (EDS) technique in conjunction with scanning electron microscopy was used for the elemental analysis of the nanoparticles. The selected area diffraction pattern recorded from single particle in the aggregates of nanoparticles revealed that the silver particles are crystalline in nature.

1. Introduction

Nanoparticles are the clusters of atoms in the size range of 1–100 nm. In this size range, materials often develop useful attributes that are distinct from the properties of the bulk material. Metal particles in the nanometre size exhibit unique physical properties that are different from both the ion and the bulk material. Their uniqueness arises specifically from higher surface to volume ratio which results in increased catalytic activity due to morphologies with highly active facets; hence, the nanosize materials are more advantageous than their bulk materials. The enhanced reactivity of nanomaterials can also be attributed to their large number of edges, corners, and high-energy surface defects [1–3]. They have tremendous applications in the area of catalysis, opto-electronics, diagnostic biological probes, display devices and photo electrochemical applications due to their unique size-dependent optical, electrical and magnetic properties [4–9].

There has been a rapid increase in microbes that are resistant to conventionally used antibiotics [10]. This has resulted in an inevitable and urgent need for development of novel antimicrobial agents. It has been known since ancient times that silver and its compounds are effective antimicrobial agents [11–13]. Compared with other metals, silver exhibits higher toxicity to broad spectrum of microorganisms while it exhibits lower toxicity to mammalian cells [14]. Silver ion has been known to be effective against a broad range of microorganisms including antibiotic-resistant strains [15]. Silver nanoparticles with higher surface to volume ratio compared to common metallic silver have shown better antimicrobial activity.

* Corresponding author. Tel.: +91 9436102171; fax: +91 3642550076.
E-mail address: srjoshi2006@yahoo.co.in (S.R. Joshi).

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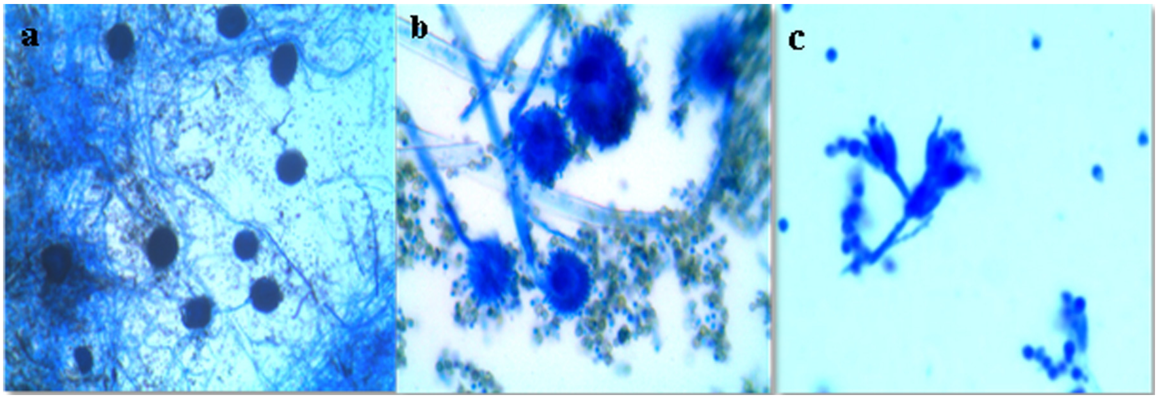

Fig. 1. Reproductive structures of the endophytic fungal isolates as seen under compound microscope: (a) PFL2, (b) PFR6 and (c) PFR8.

Most importantly silver nanoparticles are also non-toxic to the mammalian cells at low concentrations [16]. Silver nanoparticles have been known for a long time but have not been given due attention [17]. Nanoparticles can disturb functions of cell membranes such as permeability and respiration. The silver nanoparticles get attached to the cell membrane and also penetrate inside the bacteria. Inside the bacterial cells silver nanoparticles can disturb the functions of sulfur-containing proteins and phosphorus-containing compounds such as DNA by effectively reacting with them leading to the inhibition of enzyme functions [18,19]. The nanoparticles bind to proteins and DNA and damage them by inhibiting replication. Thus the silver nanoparticles interrupt the respiratory chain and cell division leading to cell death [20–22]. In addition, complex action mechanisms of metals decrease the probability of bacteria developing resistance to them [23]. Thus, one of the promising approaches for overcoming antibiotic resistance of microorganisms is the use of silver nanoparticles.

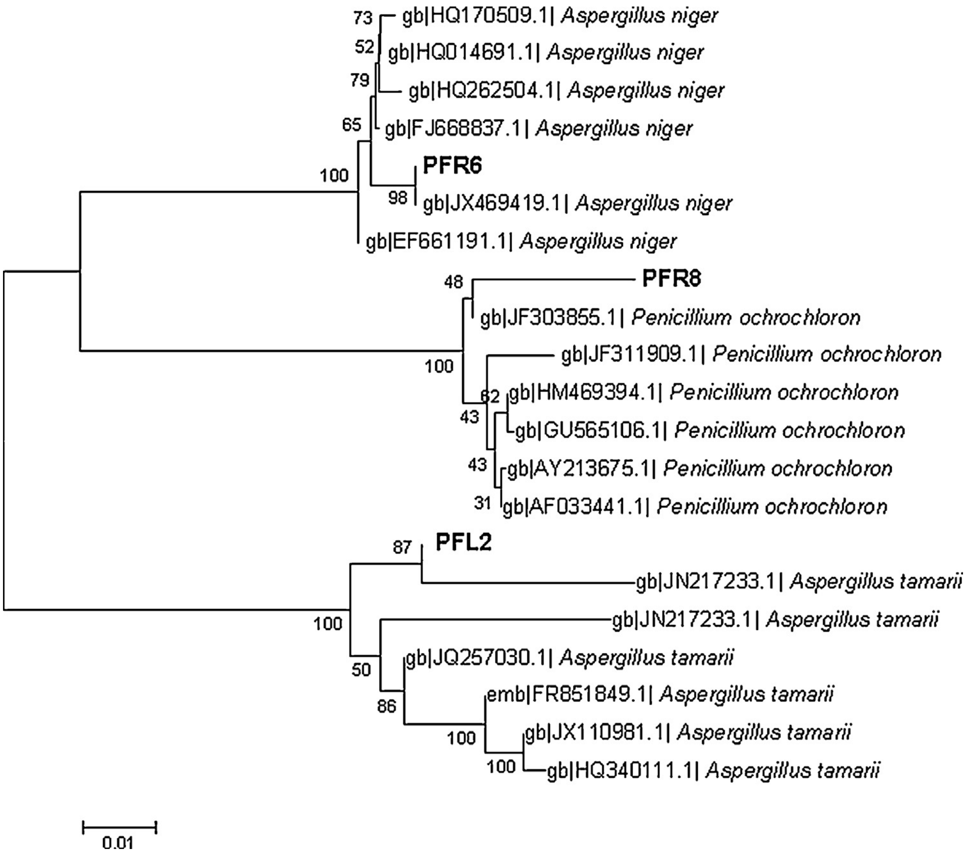

Fig. 2. Phylogenetic relationships between the three endophytic fungi and the ITS sequences of closely related fungal strains retrieved from NCBI GenBank.