Journal of Photochemistry & Photobiology, B: Biology 167 (2017) 282–289

Contents lists available at ScienceDirect

Journal of Photochemistry & Photobiology, B: Biology

journal homepage: www.elsevier.com/locate/jphotobiol

Synthesis of silver nanoparticles (Ag NPs) for anticancer activities (MCF 7 breast and A549 lung cell lines) of the crude extract of *Syzygium aromaticum*

K Venugopal [a], H A Rather [a], K Rajagopal [a], M P Shanthi [b], K Sheriff [c], M Illiyas [c], R A Rather [c], E Manikandan [a,e,f,g,*], S Uvarajan [e], M Bhaskar [d], M Maaza [f,g]

[a] Department of Biotechnology, Vels University, Chennai, India
[b] Dept of Zoology, Nehru Memorial College, Puthanampatti-621007, Tiruchirappalli, Tamil Nadu, India
[c] Dept of Virology, King Institute of Preventive Medicine and Research, Chennai 600032, India
[d] Dept of Zoology, UGC SAP-DSA-I, Sri Venkateswara University, Tirupati 517502, India
[e] Dept of Physics & Biochemistry, TUCAS, Thennangur-604408, Thiruvalluvar University, Serkadu, Vellore, India
[f] UNESCO-UNISA AFNET in Nanosciences/Nanotechnology, College of Graduate Studies, University of South Africa, Muckleneuk Ridge, PO BOX 392, Pretoria, South Africa
[g] Nanosciences African Network (NANO-AFNET), Materials Research Department, iThemba LABS–National Research Foundation (NRF), 1 Old Faure Road, Somerset West, PO BOX 722, Western Cape, South Africa

ARTICLE INFO

Article history:
Received 15 October 2016
Accepted 5 December 2016
Available online 20 December 2016

Keywords:
Silver nanoparticles
Phytochemical synthesis
Characterizations
Anticancer activities
Cellines

ABSTRACT

In the present report, silver nanoparticles were synthesized using *Piper nigrum* extract for *in vitro* cytotoxicity efficacy against MCF-7 and HEP-2 cells. The silver nanoparticles (AgNPs) were formed within 20 min and after preliminarily confirmation by UV–Visible spectroscopy (strong peak observed at ~441 nm), they were characterized by using FT-IR and HR-TEM. The TEM images show spherical shape of biosynthesized AgNPs with particle size in the range 5–40 nm while as compositional analysis were observed by EDAX. MTT assays were carried out for cytotoxicity of various concentrations of biosynthesized silver nanoparticles and *Piper nigrum* extract ranging from 10 to 100 μg. The biosynthesized silver nanoparticles showed a significant anticancer activity against both MCF-7 and Hep-2 cells compared to *Piper nigrum* extract which was dose dependent. Our study thus revealed an excellent application of greenly synthesized silver nanoparticles using *Piper nigrum*. The study further suggested the potential therapeutic use of these nanoparticles in cancer study.

1. Introduction

Nanoparticles, the rudiments for nanotechnology, are nowadays produced using noble metals like Ag, Pt, Au and Pd with the advancement of new materials with nanometer size including nanoparticles, nanotubes, nanowires, and so forth. In the recent times, silver nanoparticles (AgNPs) have attracted intensive research interest because of their advantageous applications in biomedical [1–3], drug delivery [4], food industries [5], agriculture [6], textile industries [7], water treatment [8], catalysis and surface-enhanced Raman scattering [9].

Diverse methods are used for the synthesis of silver nanoparticles. And the most commonly available known method is the chemical reduction of metal salt precursor using chemical reducing agents such as, citrate [10], polymer substances [11–13], borohydride, *N*,*N*-dimethyl formamide [14], sodium borohydride [15], trisodium citrate [16], sodium hydroxide [17], 2-mercaptobenzimidazole [18], sodium dodecyl sulfate [19], or other organic reagents [20–23]. The physical methods include, laser ablation method [24], sono chemical deposition [25,26], photochemical reduction [27,28], gamma ray and solar irradiation [29], UV photo reduction [19], microwave-assisted [30], electrochemical method [31–33], thermal decomposition in organic solvents [34], and molecular beam epitaxy methods [35].

Although the commercial methodologies have proven as efficient tools for synthesizing AgNPs, but their continuous use may pose a great threat to human health and the environment because of the use of toxic and hazardous reagents and generation of toxic by-products in some instances. These products tend to bind to the AgNPs surface and may adversely affect their character and performance [36]. Hence, there is a great need to find alternative methods for AgNP synthesis, which are nontoxic and eco-friendly.

However, these methods suffer from disadvantages like low yield, high-energy supplies, and a need for complicated and inefficient purifications [37]. Some of the recently developed green methods utilizing

* Corresponding author at: Department of Biotechnology, Vels University, Chennai, India.
E-mail addresses: ammaaappa@gmail.com, maniphysics@gmail.com, mani@tlabs.ac.za (E. Manikandan).

http://dx.doi.org/10.1016/j.jphotobiol.2016.12.013
1011-1344/

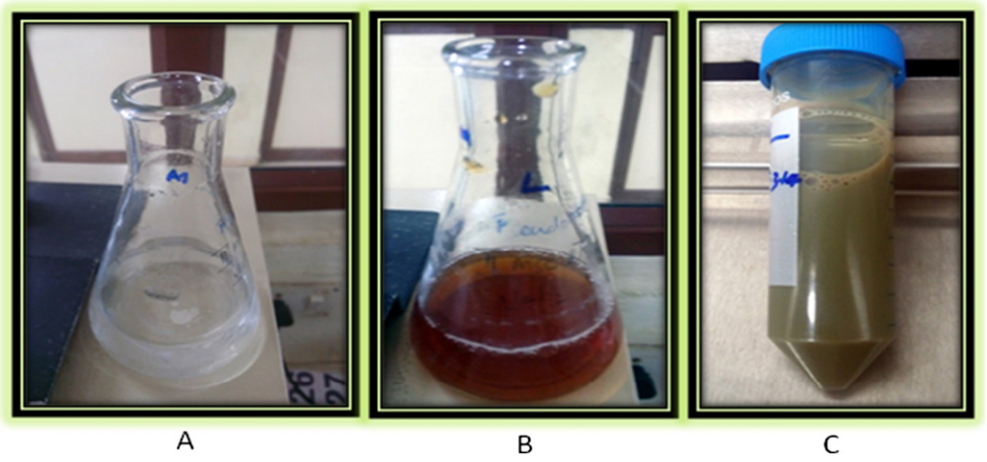

Fig. 1. Nanoparticle synthesis using *Syzygium aromaticum* plant extract; (A) silver nitrate solution, (B) *Syzygium aromaticum* extract broth, (C) silver nanoparticle solution.

biological materials show favorable routes for their synthesis. The use of plants for the synthesis of AgNPs is in the focus of intensive research because of its eco-friendly nature. The use of plants boasts of several advantages such as the elimination of elaborate processes of maintaining cell cultures, easy scale up for large-scale synthesis and cost-effectiveness. Moreover, plant extracts may act both as reducing agents and stabilizing agents in the synthesis of nanoparticles [38]. Typically, a plant-extract-mediated bio-reduction for photosynthesis of silver nanoparticles involves mixing the aqueous extract with an aqueous solution of the silver nitrate salt [39–44].

The present study directs the advantageous of silver nanoparticles from silver nitrate through a simple green route utilizing the extract of Cloves (*Syzygium aromaticum*) as the reducing agent. Cloves (*Syzygium aromaticum*), are the aromatic flower buds of a tree in the family Myrtaceae and numerous restorative uses have been most broadly connected to a toothache, and for mouth and throat aggravation. Cloves show antiseptic, antibacterial, antifungal and antiviral properties. Thus, the study proceeds with the synthesis of silver nanoparticles utilizing *Syzygium aromaticum* and their cytotoxicity of biosynthesized silver nanoparticles was studied against MCF-7 and A549 cancer cell lines. However, the synthesis of silver nanoparticles utilizing cloves as biosource has not yet been studied.

2. Materials and Methods

2.1. Materials

Silver nitrate ($AgNO_3$) and MTT were purchased from Hi-Media Laboratories Pvt. Ltd. India. The MCF-7 cancer cell line was collected from King Institute of Preventive Medicine and Research, Chennai, India.

2.2. Preparation of Clove Extract

The *Syzygium aromaticum* (Cloves) were collected from the local market and authenticated. The *Syzygium aromaticum* were finely powdered using mortar and pestle. The plant powder (20 g) was dissolved in 100 ml of millipore water and the mixture was bubbled at 80 °C for 10 min followed by filtration through Whatman Grade No. 1 filter Paper (11 μm) and the broth was stored at low temperature till further use [45,46].

2.3. Biosynthesis of Silver Nanoparticles

Syzygium aromaticum concentrate (10 ml) was added to 90 ml of 1 mM silver nitrate solution in order to achieve reduction of Ag^+ ions. Various temperatures such as room temperature (RT), 40, 60, and 80 °C were maintained using a water bath to obtain the optimum synthesis. The solution was stirred at 1000 rpm for 10 min [47]. The color change was observed at various temperatures to ensure the formation of silver nanoparticles. The *Syzygium aromaticum* clove extract was thus employed as a reducing and stabilizing agent for 1 mM of silver nitrate [48,49].

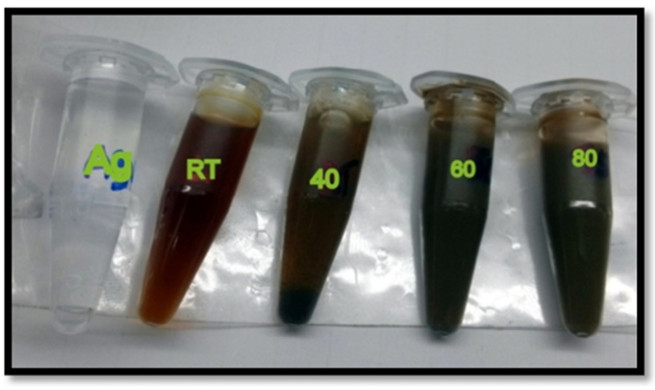

Fig. 2. Silver nanoparticles synthesized at various temperature.

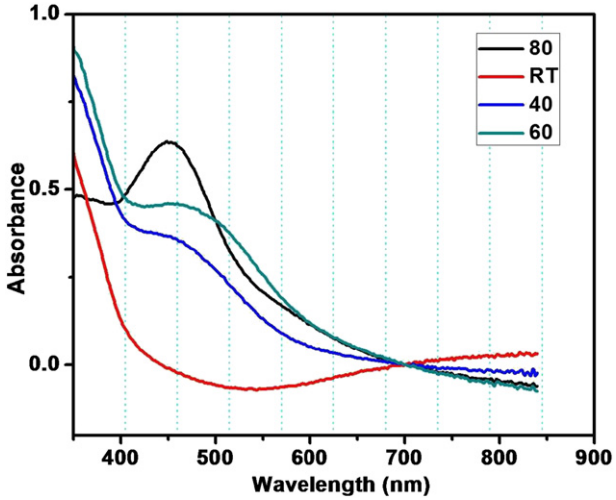

Fig. 3. UV–Vis spectra analysis of biosynthesized AgNPs at different temperatures.