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# A Comparative Study on the Synthesis, Characterization, and Antioxidant Activity of Green and Chemically Synthesized Silver Nanoparticles

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**Abstract**
Silver nanoparticles have been synthesized using green and chemical methods. *Mussaenda frondosa* (*M. frondosa*) leaf extract and sodium citrate used as reducing and stabilizing agents for the synthesis of silver nanoparticles (AgNPs) in green and chemical methods. The synthesized nanoparticles were characterized using UV-vis spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, X-ray diffraction (XRD), thermal gravimetric analysis (TGA), and transmission electron microscopy (TEM). The antioxidant activity of green and chemically synthesized nanoparticles was evaluated by DPPH (1, 1-Diphenyl-2-picrylhydrazyl) assay and observed that green synthesized nanoparticles possess remarkable antioxidant activity compared to chemically synthesized nanoparticles and it can be used for enormous applications in the biomedical field. The present study enlightens the importance of green synthesized AgNPs using *M. frondosa* leaf extract over the chemically synthesized one.

**Keywords** Green synthesis · Chemical synthesis · *M. frondosa* · Antioxidant activity

## 1 Introduction

Over the past few decades, researchers have more focuses on nanoscience because of its tremendous applications in different fields of science. Nanoparticles possess improved physical and chemical properties as compared to the bulk because of increased surface area to volume ratio. Noble metal nanoparticles like Au [1, 2], Ag [3], Pt [4], and Pd [5] are found to have significant applications in catalysis, nanoelectronics, and nanomedicine by the virtue of their unique electronic, magnetic, and chemical properties. Tunability of properties like size, shape, and composition receives particular attention and incredible applications [6]. Among the noble metal nanoparticles, silver has gained boundless applications in the nano field because of their unique properties such as chemical stability [7], good conductivity [8], catalytic [3], and most importantly antimicrobial activities [9]. Thus, nanosilver is widely used in biology and medicine, but insufficiency makes them expensive and limits its applications. To conquer this problem, numerous synthesis methods have been developed [10]. The majority of the existing procedures used for nanoparticle synthesis rely upon physical and chemical methods; these methods are sometimes toxic and potentially hazardous to the environment and living organisms [11].

Fungi [12], bacteria [13], enzymes [14], and plants [15] are used as an alternative environmentally safe method for the synthesis of nanoparticles. Among all these biological methods, the synthesis of nanoparticles by using plant extracts is widely accepted since it is a simple, cost-effective, eco-friendly method. Here the plant extracts act as both reducing and stabilizing agents and also eliminate the tangled process of maintenance of microbial cultures [16]. Green synthesis of nanoparticles using plant extracts is a novel approach to develop environmentally benign nanoparticles that can be used for various applications. It is a unique, efficient, inexpensive, and environmentally safe method for synthesizing nanoparticles with specific and selective properties and applications. Recently, AgNPs are gaining more attention because of their widespread application in different fields of science. AgNPs with varying size 30–50 nm have been synthesized by using

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