Green synthesis of silver nanoparticles from *Justicia adhatoda* plant extract with its diverse properties

Rajalekshmi¹, Roshny Lohithan², Rakhi Raj³, Priyanka Prakash³, Abhirami Santosh², Theertha V² and Smitha Chandran²

¹Department of Chemistry, SD College, Alappuzha, Kerala, India
²Department of Chemistry, Amrita Vishwa Vidyapeetham, Amritapuri Campus, Kollam, Kerala, India

Abstract. In the past few years, the science of nanostructure and technology has gained magnificent attention in the worldwide area of research and technology because of its capability to show various applications which are high thermal and electrical properties, magnetic properties, optical properties, catalytic properties, mechanical properties etc. These properties suits them for different technology and uses such as drug design, pharmaceuticals, space applications, cosmetics, medical industries, photo imaging, nano sensors used for the detection and monitoring of biomolecules. It is also suitable in the environmental field of mosquiticidal, antimicrobial properties. This article is basically focused on the synthesis of silver nanoparticles in a greener procedure by using the leaves of *Justicia adhatoda* (also called as Malabar nut) which is a medicinal plant used for cough, asthma, allergic conditions, excessive uterine bleeding, heavy menstruation etc. and is seen in various parts of India. The silver nanoparticles once synthesized were characterized using UV-Visible spectroscopy and XRD technique. Later, the particles were analysed for antimicrobial activity against two strains of microorganisms. This greener method that we used is simple, economically feasible, environment friendly and does not produce any harmful substances.

1. Introduction

The nano material which constitutes distinguishing physicochemical properties, has the capability to build new devices, structures and nano platforms with upcoming endeavours in huge variety of disciplines. The quirky size dependant properties of nanomaterials make these materials highly ranked and necessary in numerous areas of research and human activities. Unique properties of nanomaterials like large surface area, small size and specific reactivity allows it to be used in a wide range of applications like catalysts and fuel cells. Nanoparticles have the unique ability to self-assemble, this ability along with its other characteristics like small size and large surface area gives it certain distinct properties like optical activities, high thermal conductivity, magnetic behaviour etc.

Numerous techniques are known for the synthesis of nanoparticles. Some of the conventional techniques produce bulk amount of nanoparticles in a short notice of time, but such techniques make
use of large amount of harmful chemicals as the stabilising and reducing agents and that can result in environmental toxicity. To get rid of chemical toxicity in environment, a greener approach is used in the synthesis of metal nanoparticles. In this method metal nanoparticles are synthesised from plant extracts and other biodegradable products that are easily available in the environment. This is a useful technique for regulating chemical synthesis, and it allows the nanoparticles to take a distinct shape and size with a careful synthesis [1-4].

Silver nanoparticles are considered as one of the widely used type as it has a variety of applications in fields like optics, selective coatings for solar energy absorption, bio labelling, bio sensing and antibacterial agents due to their extensive properties. In case of antibacterial applications, uses of silver nanoparticles are preferred over all the other types of metal nanoparticles due to its non-toxic behaviour towards humans. A wide variety of plant species are tested in order to check its ability to synthesis AgNP. Most of the studies are done in plants species encompassing vegetables, fruits, cereals, spices, medicinal and other food items which already have lot of other uses. Polysaccharides, Alkaloids, flavonoids, proteins etc. present in the plant extracts ate used as the reducing and capping agents in Green synthesis of AgNP [5-6].

The present work emphasis on the production of AgNP’s from Justicia adhatoda leaf extract, commonly known as Malabar Nut in a greener approach and to investigate the antimicrobial activities of the AgNP thus synthesised.

2. Materials and Methods

*Justicia adhatoda*

Justicia adhatodacommonly called Malabar nut is a medicinal plant found in many parts of India. This is widely used in Ayurvedic, homeopathy and siddha medicine system. This belongs to the family Acanthaceae. This plant is commonly found in various parts of Kerala and extracts of this plant is used in the Greener synthesis of AgNP.

Green synthesis of AgNP from Justicia adhatoda extract.

The plant materials were collected from the nearby areas of campus. These plant parts were washed first with normal water and then with deionised water in order to remove adhered debris. It was then air dried and chopped into small pieces, exactly 5gram of which is weighed and allowed to boil in 25ml of deionised water so that the extract is completely dissolved in the water. The extract was then allowed to cool and filtered. 5ml of the filtrate is accurately measured and it is mixed with 50ml of 1millimolar silver nitrate solution. The extract acts both as reducing and stabilising agents [1, 7]. The silver nanoparticles formed can be identified by the instant colour change of the solution (Figure 1) and then it is confirmed by UV-Visible spectroscopy(Figure 2). All the chemicals used in the study are obtained from Merck.

Antimicrobial study

The capability of synthesised silver nanoparticles to resist the growth of various microorganisms was studied using a gram negative and positive bacterium. The whole procedure was done by following the guidelines of Clinical Laboratory Standards Institute (CLSI). A bacterial Culture was prepared. Bacteria used were Staphylococcus aureus (gram positive) and Escherichia coli (gram negative). These cultures were then spread on an agar plate and the synthesised silver nanoparticles were poured into it. It is incubated for 24 hours at 37°C. The zone of inhibition was then calculated by measuring the diameter.
3. Results and Discussions

The plant extract is able to reduce Ag$^+$ to Ag$^0$, it also acts as the stabilizing agent for the aggregating silver atom at the level of nanoparticles formation. The formation of AgNP’s was identified by the instant colour change of the solution (Figure1) and it is confirmed by UV spectroscopy (Figure2). A peak is observed at 455.04322nm as a result of surface plasmon resonance which is a characteristic property of nanoparticles. The powdered XRD spectrum also confirmed the generation of silver nanoparticles.

![Figure 1. Instant colour change of the extract indicating the formation of silver nanoparticles](image1)

![Figure 2. UV- spectrum of analysis of silver nanoparticles.](image2)

A. Study on antimicrobial property.

The silver nanoparticles produced are now analysed for their antimicrobial activity. A culture plate inoculated with a gram positive (staphylococcus aureus) and a gram negative (Escherichia coli) bacteria were taken for this purpose. The prepared extracts were poured into it and incubated for 24
hours at 37°C. The presence of an inhibition zone for these bacteria confirms the antimicrobial activity of the synthesised nanoparticles.

4. Conclusion

The work put forward a novel approach for the formation of silver nanoparticles from *Justiciaadhatoda* in a greener pathway. This method makes sure that no toxic or harmful by-products are produced; it goes hand in hand with the environment. This method also does not require any use of sophisticated laboratory conditions and very low amounts of chemicals are used. Furthermore, the study put forward a method towards the antimicrobial studies. This method can be utilized as an inexpensive and environmentally safe one in the preparation of AgNP’s along with multiple applications in different fields.

REFERENCES

[1] Priyanka Prakash, Abhirami Santhosh, Theertha V, Rini John, Nandhakumar G and Smitha Chandran S2020Environmentally benign synthesis of silver nanoparticles using *Cynodondactylon* coupled with multiple applications *Materials Today: proceedings* 25 Part 2 333-335

[2] Sreeram KJ, Nidin M and Nair BU 2008 Microwave assisted template synthesis of silver nanoparticles *Bull Mater Sci* 31 No.2 937-942

[3] Begum N A, Mondal S, Basu S, Laskar R A and Mandal D 2009Biogenic synthesis of Au and Ag nanoparticles using aqueous solution of black tea leaf extracts *Colloids Surf B Biointerfaces* 7 No1 pp 113-118

[4] Li, S Shen, Y, Xie, A, Yu.X, Qiu, L, Zhang, L, Zhang, Q 2007 Green synthesis of silver nanoparticles using Capsicum annuum L. extract*Green Chem* 9 pp 852-858

[5] Song Y M and Kim B S2009Rapid biological synthesis of silver nanoparticles using plant leaf extracts *Bioprocess. Biosyst. Eng* 32 pp 79-84

[6] Krishnaraj C, Jagan EG, Rajasekar S, Selvakumar P, Kalaichelvan PT and Mihan N 2010Synthesis of silver nanoparticles using *Acalyphaindica* leaf extracts and its antibacterial activity against water borne pathogens *Colloids and Surfaces B: Biointerfaces* 76 pp 50-56

[7] KarunakarRaoKudle, Manisha R Donda, JahnaviAlwala, Rama Koyyati, VeerababuNagati,RamchanderMerugu, Prashanthi Y, Pratap Rudra M P 2012Biofabrication of silver nanoparticles using Cuminumcyminum through microwave irradiation *International Journal of Nanomaterials and Biostructures* 2 No. 4 pp 65-69