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Antibacterial Activity of Biofabricated Molybdenum Nanoparticles

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The study is the first report on Molybdenum nanoparticles synthesis using wood apple shell extract. Microorganisms, fungus, enzymes and plants are used for biosynthesis of nanoparticle, which acts as ecofriendly alternative to chemical and physical methods. Molybdenum nanoparticles or nanopowder are black high surface area particles. The Molybdenum nanoparticle was synthesised using *Wood Apple* shell extract through calcination process. The characterization of synthesized Molybdenum nanoparticles was done using UV Visible spectroscopy, Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Electron Microscopy (SEM). The UV-Visible spectroscopic analysis showed maximum absorption peak at 260 nm. The observed spectrum of FTIR analysis shows distinct bands at 2735.29 cm^{-1}, 2396.44 cm^{-1}, 1763.99 cm^{-1}, 1383.79 cm^{-1}, 875.15 cm^{-1} and 825.74 cm^{-1}. In SEM study the shape of Molybdenum nanoparticles was found to be spherical. The antibacterial activity of Molybdenum nanoparticles is studied against Gram positive and Gram negative broth cultures and highest inhibitory effect was observed for Gram negative bacteria *Proteus mirabilis* and *Klebsiella pneumonia.* These findings confirm that the Molybdenum nanoparticle has complimentary potential to treat various bacterial infections like Urinary tract infection, Blood stream infections and Meningitis.

Keywords: Application, Aqueous extract, Biosynthesis, Characterization, Wood apple shell

Introduction

Nanotechnology is combination of both engineering and science, includes size, the production of chemical compounds, and the creation of frictional characterized molecules. Nanotechnology is applied mainly in pharmacology field.[1] Nanoparticles (NPs) are very small materials and its size range from 1 to 100 nm. Nanoparticles are categorised into different classes according to their properties, structure and size. This includes metal NPs, fullerenes, ceramic NPs and polymeric NPs. Depending on the size of the NPs the optical properties are reported. The process of making of nanoparticles involves either chemical or biological method. There are many harmful effects associated with the chemical synthesis methods. Because chemical synthesis methods contains some toxic chemical absorbed on the surface of nanoparticles. Micro organisms, fungus, enzymes and plants are used for nanoparticles synthesis in biological ways, which act as ecofriendly alternatives to chemical and physical methods. The enhancement of these ecofriendly methods for the synthesis of nanoparticles is evolving into a crucial stream of nanotechnology especially silver nanoparticles, which consist of many applications. Biosynthesis of nanoparticles which are produced by microorganisms is a green and ecofriendly technology. Synthesis of metallic nanoparticles such as silver, gold, platinum, zirconium, palladium, iron, calcium and metal oxides such as titanium oxide, zinc oxide and so on, utilize a diverse microorganisms and different plant extracts. The synthesis of nanoparticles may be intracellular, in accordance with the location of nanoparticles.[2] As a source of plant extract wood apple has a great potential.

Wood Apple *Limonia acidissima* is an edible fruit. The wood apple is native of India and other countries such as Pakistan, Sri-Lanka and Bangladesh. The other name of this fruit is Elephant-apple, monkey fruit or crud fruit. The fruit contains fruit acids, vitamins and minerals. The pulp of the fruit, especially when unripe, is used in the treatment of diarrhoea and dysentery. It has got astringent properties.

Ecotoxicity of nanoparticles has been a debate for researchers since it has been emerged. The entire process of production of nanoparticles through biosynthesis must be a reliable, non toxic and sustainable alternative to conventional chemical and physical methods of production.[3] The synthesis of stable Molybdenum and Molybdenum oxide nano and

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micro particles have taken place only in Ionic Liquids (ILs) with various anions under reducing conditions.[4] Preparation of Molybdenum disulphide nanoparticles has been done using hydrothermal method. The sample which is obtained is confirmed as 3R (Rhombohedral) structures with their repeating layers of molybdenum and sulphur.[5] The decrease in binding energy with the change of oxidation states was observed. Molybdenum oxide nanoparticles were combined using the citrate obtained from sol-gel method and analysed for SEM and X-ray diffraction techniques. The examination of the sensitivity of the material to the presence of various gases was done which results in showing higher sensitivity towards NO_2 gas by the Molybdenum nanoparticles.[6]

The current study reports an economical and eco friendly method of Molybdenum nanoparticles synthesis. The study is focused with the synthesis and characterization of Molybdenum nanoparticles using wood apple shell extract and demonstrated its antibacterial nature.

Materials and Methods

Collection of Wood apple shell

The Wood Apple was purchased from a fruit stall in Tirupattur district, Tamilnadu, India and their shell extract is used for preparing Molybdenum nanoparticle and studied for their Antibacterial activity.

Preparation of Shell Extract

Wood apple shell was washed thoroughly with double distilled water and sun-dried. Following complete drying, the shell was powdered into fine particles. Then the 5 g wood apple shell powder is boiled with 25 mL of double distilled water for 60 min at 100°C and it is cooled and filtered.

Synthesis of Molybdenum Nanoparticles

Added the plant sample extract to 1 g of Ammonium molybdenum in Erlenmeyer flask. The flask was kept on a magnetic stirrer at 100°C temperature until the solution changes into powder form. Then the powder has to be dried and calcinated in Muffle furnace at 500°C for 2 hours. Mo nanoparticles thus obtained was stored in an air tight container for further characterization studies.

Characterization studies

The Nanoparticles synthesized was confirmed by recording the UV-Vis spectra at periodic time intervals until the absorption maximum reached saturation. FTIR analysis was performed to classify the groups which are responsible for reduction of the material and for the stabilization of nanoparticles (i.e) the functional group responsible for the Mo nanoparticle. Scanning electron microscopy (SEM) was done to study the morphology of the synthesized Mo nanoparticles.

Antibacterial Activity

Antibacterial tests were carried out by the agar well diffusion method using the suspension spread on nutrient agar. Dip the swab into the broth culture of the organism. Gently squeeze the swab against inside of the tube to remove excess fluid. Use the swab to streak a nutrient agar plate for a lawn of growth. The samples were loaded in the well, in the range of 50 μL, 100 μL, 150 μL, 200 μL and the DMSO was used as the control. Then the inoculated plates were incubated at 37°C for 24 h and then the zone of inhibition was measured.

Results and Discussion

Analysis Through UV-Visible Spectrophotometer

The Molybdenum nanoparticle synthesised using wood apple shell extract has been preliminarily confirmed by measuring the maximum absorption range using UV-Visible spectrophotometer between the wavelength intervals of 200-1100 nm. The absorption maximum for Molybdenum nanoparticle prepared using wood apple shell extract was obtained at 260 nm as shown in the Fig. 1. The maximum UV absorption correspond to the maximum absorption band of Molybdenum oxide nanoparticles.[7]

Analysis Through FTIR

FTIR analysis is an analytical technique used to detect organic, polymeric and in some cases, inorganic materials and to observe chemical properties. The FTIR analysis has been performed to classify the group which is responsible for reduction of the material and for the stabilization of nanoparticles. Similar results have been confirmed by Pannipa *et al*.,[8] in Synthesis of h- and α-MoO_3 by

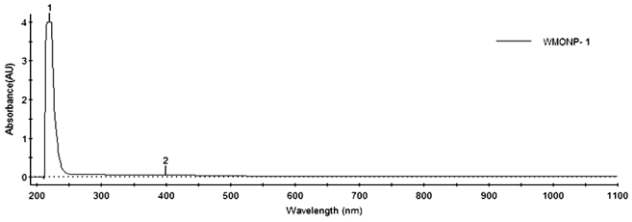

Fig. 1 — Molybdenum nanoparticle UV-Visible spectrum

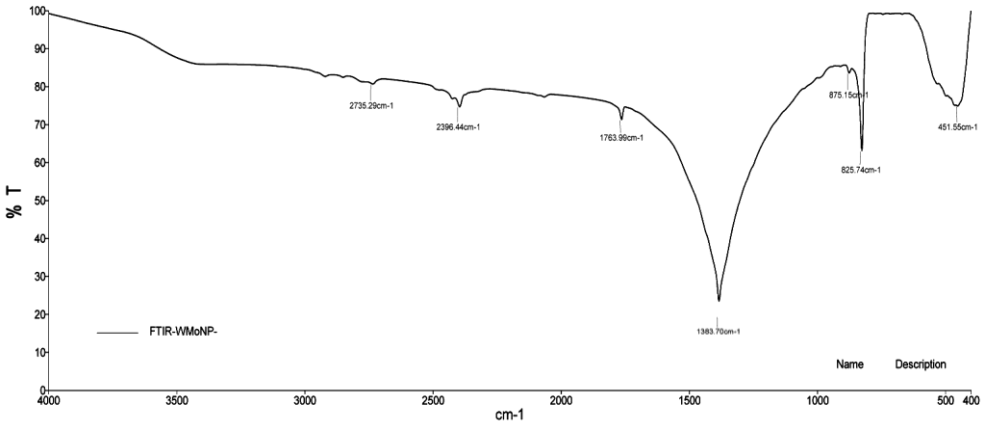

Fig. 2 — Molybdenum nanoparticle FTIR spectrums

Table 1— Functional groups in Molybdenum nanoparticle corresponding to FTIR spectrum

Characteristic Absorption(s) (cm^{-1})	Functional Group
2735.29cm^{-1}	O-H
2396.44cm^{-1}	C=N
1763.99cm^{-1}	C=O
1383.79cm^{-1}	C-O

Refluxing and calcinations, combination: phase and morphology, transformation, photocatalysis and photosensitization.

FTIR spectra shown in Fig. 2, have distinct bands at 2735.29 cm^{-1}, 2396.44 cm^{-1}, 1763.99 cm^{-1} and 1383.79 cm^{-1} which are due to the formation of Mo nanoparticles by the phytochemicals present in the wood apple shell extract. The bands at 875.15 cm^{-1} and 825.74 cm^{-1} corresponds to Mo-O-Mo stretching.[9] This data confirms the synthesis of Molybdenum nanoparticles. The functional groups corresponding to the FTIR spectra obtained is shown in the Table 1.

Analysis through SEM

Scanning electron microscopy is a test process used to scan sample morphology. For SEM analysis Mo nanoparticle fine powder was used. Molybdenum nanoparticle (Fig. 3) showed spherical shape in SEM microstructure.[10] The molybdenum nanoparticles synthesised using wood apple shell extract are poly dispersive and the size varies between 81 nm to 105 nm.

Antibacterial Activity

The antibacterial activity of Mo nanoparticles was studied for five different pathogenic organisms carried out by the agar well diffusion method. The zone of inhibition (mm) around each well containing Mo nanoparticles was shown in the Table 2.

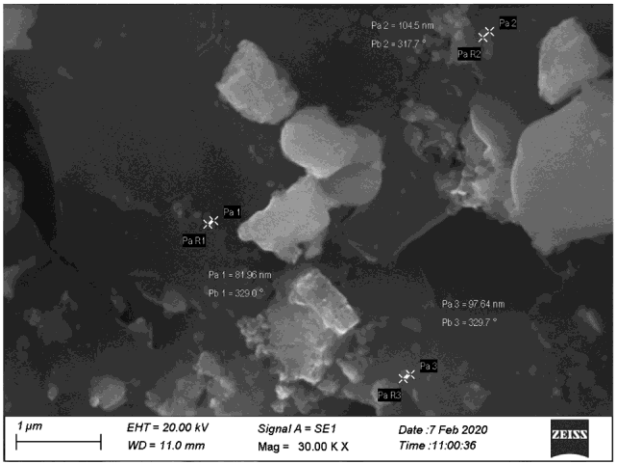

Fig. 3 — Scanning electron microscopy image of Mo nanoparticle synthesised using wood apple shell extract

Table 2 — Antibacterial activity of Molybdenum nanoparticles

S.No	Organisms	DMSO	Concentration of ZnO nanoparticles			
			50µl	100µl	150µl	200µl
			Zone of inhibition (Diameter in mm)			
1.	*Proteus mirabilis*	NIL	8	10	13	14
2.	*Klebsiella pneumonia*	NIL	NIL	11	12	12
3.	*Escherichia coli*	NIL	NIL	NIL	NIL	NIL
4.	*Salmonella typhi*	NIL	NIL	NIL	NIL	NIL
5.	*Staphylococcus aureus*	NIL	NIL	NIL	NIL	NIL

Molybdenum nanoparticle is found to be active against *Proteus mirabilis* showing zone of inhibition at the concentration of 50 µl, 100 µl, 150 µl and 200 µl (0.1 gm/mL of Mo nanoparticle) whereas *Klebsiella pneumonia*[11] shows zone of inhibition only at the concentration of 100 µl, 150 µl and 200 µl and there is no zone of inhibition for 50 µl. The molybdenum nanoparticles prepared using wood

Fig. 4 — Antibacterial activity of Molybdenum nanoparticles

apple shell extract was not having activity against *E. coli, S. typhi and S. aureus*. The positive results are captured and shown in the Fig. 4.

Conclusions

Nanoparticles have many medicinal uses and it was used as drug delivery system to the target. Ammonium molybdate was converted to Molybdenum nano-particles using wood apple shell powder extract in ecofriendly method out of waste. In UV-Visible spectroscopy, the synthesised Molybdenum nano-particles showed maximum absorption peak at 260 nm. In FTIR analysis the different functional groups that are involved in the formation of Molybdenum nanoparticle was observed. In SEM study, the shape of Mo nanoparticle was found to be spherical. The antibacterial activity of Molybdenum nanoparticle was done by using Agar well diffusion method. The Mo nanoparticles synthesised using wood apple shell extract shows antibacterial activity against the *Proteus mirabilis* and *Klebsiella pneumoniae*. These findings confirm that the Molybdenum nanoparticles have a complimentary potential to treat various bacterial infections like Urinary tract infection, Bloodstream infection and Meningitis.

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