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Nanoparticles and its Green Synthesis using *Moringa pterygasperma* Lam: A Review

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Abstract

Nanomaterials have vibrant properties and it has been used for varied applications in worldwide. Nowadays, humans have started loving nature which provides health benefits without side effects. This study contributes to a survey of naturally derived nanoparticles which are beneficial to various applications. Moringaceae is the family name of *Moringa pterygasperma* lam and it is the superfluous name for *Moringa oleifera*. *Moringa pterygasperma* lam is a naturally available plant resource that has anti-microbial, anti-bacterial and photocatalytic properties. The extracts of seeds, gum, leaves, drumsticks, and roots, are used to prepare nanoparticles by green method that can be used in food packing, medical and environmental applications. The extracts of the plant parts were used as a reducing agent to synthesize nanoparticles from metal ions to metal. Also, it is used as a stabilizing and capping agent during their synthesis. The formation of metal nanoparticles was confirmed by the result of UV-Vis spectroscopy (UV-Vis), Fourier Transform Infrared Spectroscopy (FTIR), X-Ray Diffraction analysis (XRD), and Transmission Electron Microscopy (TEM) showed less than 100 nm in size.

Keywords: Nanoparticles, Synthesis, Plant Extracts, Moringaceae, Reducing Agent, Capping Agent

1. Introduction

Nanomaterials have a relatively larger surface area when compared to the same mass of material produced in macro size. So the material in nano size is more reactive than macro size showing excellent properties. The list of nanomaterials is dendrimers, carbon nanotubes, polymers, liposomes, metal particles and hydrogels. Over the years, a nanoparticle has foot printed in every field with promising applications due to its high surface area. Chemical, physical, and biological are the methods to prepare nanoparticles. Recently, green synthesis has been considered as an environmental friendly method to synthesis nanoparticles. The parts (seed, gum, leaf, root and flower) of the plant extract were used for the synthesis of nanoparticles. The exact roles of extracts are template, reducing agent, stability agent and capping agent. In this view, *Moringa pterygasperma* lam plant and its parts showed biological properties and hence it is used in the synthesis of various nanoparticles including Zinc oxide (ZnO), Vanadium, Hydroxyapatite (HAP) and silver[1]. The minerals of *Moringa oleifera* are iron, calcium, potassium, zinc and magnesium. Hundred grams of *Moringa oleifera* contain 10 times more vitamin A than carrots, more than 15 times of calcium than milk and more than 20 times iron than spinach. The seeds of *Moringa oleifera* have to purify the water. *Moringa oleifera* contains vitamins, minerals, amino acids, sterols, glycosides, alkaloids and flavonoids so it is traditionally called a wonder tree. The Phytoconstituents of the *Moringa oleifera* stem contains vanillin and beta-sitosterol, root has moringine and moringinine and flowers have D-glucose and D-mannose. The bark possesses benzylgiucosinolate whereas the pod contains isothiocyanate and nitrites. Methionine and niazimicin niazirin are found in seeds Pyrrole alkaloids are found in leaves[2]. It is reported that the polyphenolic compounds have a high affinity for metal ions and hence it is used in the synthesis of nanomaterials and that took the role as reducing, stabilizing, and chelating agents. The seeds of wonder tree can also used in the production of biodiesel. In this study, the review of nanoparticles synthesis using the parts of Moringa plant extracts.

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2. Synthesis of Nanoparticles from Moringa Plant Extract

2.1 Moringa Flower for Hydroxyapatite Nanoparticle

The synthesis of Hydroxyapatite nanoparticles using the extract of moringa flower was reported by Sundrarajan *et al.*, [3]. The clear ethanolic extract of *Moringa oleifera* flower used in the synthesis of crystalline HAP. In their method, 50 ml of extract was added to calcium and phosphate precursor and stirred for 1 h at room temperature. The precipitate was washed with de-ionized water and dried. The researchers investigated how the flower extract act as a template in controlling the morphology and size of HAP nanoparticles.

2.2 *Moringa oleifera* Lam for Zinc Oxide Nanoparticles

Manokari and co-workers[4] reported the synthesis of Zinc oxide nanoparticles from *Moringa oleifera* lam extracts. The research group has differently done the synthesis process, where Moringa leaf, stems, flowers, and pods (5 g) were boiled with 50 ml of double-distilled water for 15 min and the extracts were filtered. The extracts of the wonder tree were used to synthesize zinc oxide nanoparticles and they took zinc nitrate hexahydrate ($Zn(NO_3)_2.6H_2O$) as a precursor. The bio reduction of zinc nitrate hexahydrate to zinc oxide nanoparticles using moringa extracts was monitored by UV-visible spectroscopy and that shows a strong absorption peak at 308 nm illustrate the formation of zinc oxide nanoparticles.

2.3 Moringa Gum for Silver Nanoparticles

The water-soluble biopolymer Moringa gum is also used in the synthesis of silver nanoparticles using the green synthesis method reported by Madhukar Rao Kudie *et al.*, [5]. Moringa gum was dried at 40 °C for one day and the gum is soluble in pure water at room temperature to get the concentration of 0.01 %. The moringa gum extract was added to 1 mM of $AgNO_3$ solution at a 1:1 ratio gives yellow-colored silver nanoparticles. This silver nanoparticle formation was confirmed by a UV-visible absorption peak found at 300–700 nm. The synthesized silver nanoparticles bearing the size of 55-91 nm showed good antimicrobial activities against *Escherichia coli, Salmonella, Bacillus cereus*, and *Pseudomonas aeruginosa*.

2.4 Moringa Leaves for Vanadium Nanoparticles

Aliyu and co-workers[6] reported the antimicrobial activity of vanadium nanoparticles using Moringa leaves. The extracts of Moringa leaf was used to synthesize vanadium nanoparticles. To Freshly prepared moringa leaves were chopped into pieces and boiled in distilled water for 5 min to get an extract. The aqueous solution of vanadium chloride (190 ml) was slowly added to 10 ml of Moringa leaf extract with continuous stirring while the V^{2+} ions were converted into the V^0. The phytochemicals in Moringa leaf act as a capping and stabilizing agent to synthesize metal nanoparticles. An antimicrobial test was carried out on a nutrient-agar showed enhanced activity against *Escherichia coli* and *Salmonella typhi* bacteria.

2.5 *Moringa oleifera* Leaves for Silver Nanoparticles

Dongale *et al.*, [7] reported the synthesis of silver nanoparticles from the extracts of Moringa leaf. The prepared silver nanoparticles were used as food-packaging materials and exhibited photocatalytic activity. Moringa leaves were washed and dried for 2–3 days, then powdered and added to 100 ml of distilled water and boiled for 20 min. The bio reduction of silver ions was carried out in 10 ml of extract with 90 ml of 1 mM of aqueous $AgNO_3$ solution heated at 80 °C for 20 min the color was changed from yellowish brown to reddish brown. The formation of silver nanoparticle was confirmed by UV-visible spectrum, XRD and FTIR. The Antimicrobial tests were taken against pathogenic bacteria like *Escherichia coli, Salmonella typhi*, *Bacillus cereus* showed appreciable anti-microbial activity. Nanomaterial was coated as packing material by dipping Low-Density Polyethylene films (LDPE) in 1 mM silver nanoparticles of colloidal solution at three different times such as 1 h, 3 h, and 5 h. The substrate was dried for 2-3 days at room temperature, and then the film was removed and optimized to prepare a 5 mm*5 mm LDPE film. The photocatalytic degradation study was also done in methylene blue and malachite green dyes where 10 mg of dye was added to 1000 ml of water for the stalk solution. The 1 mg/2 ml concentration of silver nanoparticles and was used for dye degradation was stirred for 30 min in a dark room to attain equilibrium.

2.6 *Moringa oleifera* Leaves for Hydroxyapatite Nanoparticles

Synthesis of nano-Hydroxyapatite from *Moringa oleifera* leaves as calcium precursor was reported by Govindaraj and co-workers[8]. Moringa leaf is predominantly composed of $CaCO_3$ (95 %), Calcium phosphate (1 %), organic matter (3 %), and magnesium carbonate (1 %). *Moringa oleifera* leaf has calcium rich source so, it was used as a precursor for the synthesis of hydroxyapatite. Moringa leaves were washed with Millipore water and then rinsed with acetone to remove the contaminants, dried ground into fine powder using ball milling. 1 g of *Moringa oleifera* leaf powder was mixed with 0.1 M of EDTA solution to form a Ca-EDTA complex and it was mixed with a 0.06 M $(NH_4)_2$ HPO_4 solution by slow addition, sonicated for 30 min subjected to microwave irradiation at 100 w for 5 min. The final stage of the white precipitate was washed and dried in a hot air oven. Hydroxyapatite formation was confirmed by FTIR shows sharp peaks at 3572 cm^{-1} and wide bands at 3455 cm^{-1} and 1630 cm^{-1}. The crystalline phase of hydroxyapatite was found using XRD at 002, 210, 310, 222, 213, and 004 planes. The prepared Hydroxyapatite porous nanoparticle is quite good so that the soft and hard tissue can grow inside the pores easily and it is advantageous in tissue repair engineering application.

3. Conclusion

Synthesis of silver nanoparticles, zinc oxide nanoparticles, vanadium nanoparticles and hydroxyapatite nanoparticles from various parts of *Moringa oleifera* plant were reported and showed excellent properties for various biomedical, environmental and food packing applications. The above nanoparticle has a significant efficiency in the biomedical field that is hydroxyapatite nanoparticles have tissue engineering application and silver has anti-bacterial. The environmental application of silver w as proven by its ability to degrade dyes. Silver nanoparticles were also used as food packing material in combination with LDPE. Since it has good anti-bacterial activity against gram-negative and gram-positive bacteria, green synthesized vanadium nanoparticles showed very good anti-microbial activity against pathogenic bacteria of *E. coli* and *Salmonella typhi*. Hence, the nanoparticle synthesized by the green method using the parts of Moringa plant paves the way to cost-effective approach using nature.

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