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One-Step Green Synthesis and Characterization of Flower Extract-Mediated Mercuric Oxide (HgO) Nanoparticles from *Callistemon Viminalis*.

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Research Article

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ABSTRACT

The present study demonstrates green synthesis of nanosized HgO using flower extract of an ornamental plant *Callistemon viminalis*. Till date, there is no report of synthesis of Nano particles utilizing an aqueous flower extract of *Callistemon viminalis*. In this research work, *Callistemon viminalis* flower extract in a concentrated aqueous solution of mercury (II) acetate results in HgO Nano particles. Mercuric acetate was taken as the metal precursor whereas flower extract act as a reducing as well as a stabilizing agent. The phytochemicals present in the extract act as a reducing agents, which include saponins, phenolic compounds, and flavonoids. The formation of the HgO nanoparticles was monitored by using UV-Vis absorption spectroscopy and FTIR.

INTRODUCTION

Environment friendly method for the synthesis of nanoparticles does not involve any harmful chemicals. The biological synthesis of nanoparticles using plant extracts plays an important role in the field of nanotechnology [1,2,3,4]. Green-synthesized mercuric oxide (HgO) nanoparticles were produced by treating mercuric ions with the flower extracts of an ornamental plant *Callistemon viminalis*.

The UV-Vis spectroscopy revealed the formation of HgO nanoparticles by exhibiting the typical surface Plasmon absorption maxima at 230-250nm from the UV-Vis spectrum [5]. The dried form of synthesized nanoparticles was further characterized using FTIR spectroscopy. FT-IR spectra of synthesized HgO nanoparticles were carried out to identify the possible bio molecules responsible for capping and stabilization of nanoparticles.

Bottlebrushes are members of the genus *Callistemon* and belong to the family *Myrtaceae* [6]. Plant can reach heights of 10 to 15 feet. The flowers are followed by small; woody capsules that look like bead bracelets on the bark, and which last for years [7]. Flower color are commonly red, but white, cream and pink flowers are known to exist. There are 40 species currently called *Callistemon* [6]. This small tree is native to Australia. Bottle brush is a rich source of essential nutrients; among its constituents are silicon, potassium, selenium, aluminum and manganese, along with 15 types of bioflavonoid. The *Callistemon viminalis* leaves or blossoms to make a tea or use the leaves to make a tea and use the blossom to sweeten the tea. Recent studies on the antibacterial properties of the essential oils of *Callistemon viminalis* brought the interest of scientist on other possible uses for this plant.

MATERIALS AND METHODS

Materials

Callistemon Viminalis (red bottlebrush) flower, methanol, Sodium hydroxide, Mercuric acetate was purchased from CDH, and Sterilized water.

Preparation of *callistemon viminalis* flower extract

Fresh flower of *callistemon viminalis* were collected near FASC, Mody campus and washed under running tap water to remove any debris and dust attached to the flower and subsequently with Millipore water 3-4 times. Flowers were air dried for two weeks at room temperature (25°C). The dried flowers were finely powdered through grinding using Lumix grinder. The extract was prepared by taking 40g of powdered flowers in a 500mL round flask with 300mL of sterile Millipore water and 10-12 drops of methanol. Then the above was boiled for 10 min at 80°C and sieved and filtered twice by using Watman filter paper No.42. The filtrate was collected and stored at 4°C and used within a week.

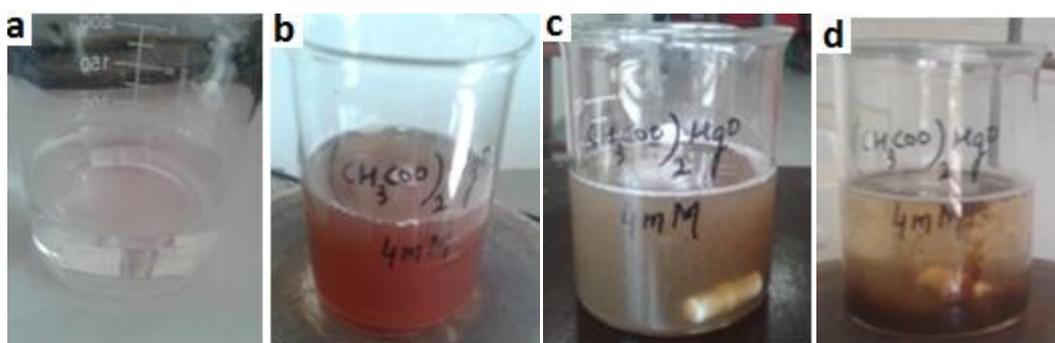
Figure 1: (a) Bright pink color flowers exhibited by *Callistemon viminalis* growing near the vicinity of Guru Vashisht College, FASC, Lakshmangarh, Sikar district of Rajasthan province of India. (b) Millipore washed flowers were room dried for two weeks. (c) Flower extracts revealed intense deep maroon color



Synthesis of Mercuric Oxide Nanoparticles

To synthesize Nano particles from *callistemon viminalis* 40mL of the aqueous flower extract were carefully added to 100mL of 0.1 M aqueous Mercuric acetate solution in 250mL Schott Duran beaker. The beaker containing the extract was incubated on a rotary shaker at 150 rpm at 60°C condition. After 10-15 min 50mL of 0.2 M aqueous Sodium hydroxide were added into the beaker containing the extract solution. Leave the solution for 15-20 min. A change in color of the colloidal solution and precipitation occurred, confirming green synthesis of HgO Nano particles.

Figure 2: Change in color of Mercuric acetate solution during the course of experiment. (a) Before treatment with flower extract. (b) After addition of flower extract. (c) Light yellow turbid (d) Dark yellow and precipitation of Mercuric oxide nanoparticles.



RESULTS AND DISCUSSIONS

UV-Vis refers to absorption spectroscopy in the UV-Visible spectral region. This means it uses light in the visible and adjacent (near-UV and near-infrared) ranges. [8] The UV-Vis spectra of HgO dispersion is presented in figure 3. The absorbance of the solution is found to increase with increasing HgO. It is noteworthy that the λ_{max} values are at around 200-250nm [5]. A broad maximum at about 243nm is observed in HgO Nano particles spectrum.

FTIR spectroscopy was used to identify the functional groups of the active components based on the peak value in the region of infrared radiation [8].

FTIR spectra of synthesized HgO Nano particles were carried out to identify the possible biomolecules responsible for capping and stabilization of Nano particles.

The peaks 3200-3550 cm^{-1} have been assigned to the O-H stretching. The peaks at 1414 and 1021 cm^{-1} are attributed to the asymmetric and symmetric stretching vibration of COO^- that proves the combination of protein with nanoparticles. The peaks at 1730 cm^{-1} shows the presence of carboxylic carbonyl group of protein, which act as a reducing agent, and reduces the peak at 1640 cm^{-1} in nanoparticle which is responsible for the presence of amide carbonyl group of protein, which is attached to nanoparticle for capping and stabilizing. The IR spectrum of HgO nanoparticles shows the absorption peaks at 650 cm^{-1} are assigned to the (HgO) mode, which confirms the formation of HgO nanoparticles [9].

Figure 3: UV-Vis of HgO Nano particles

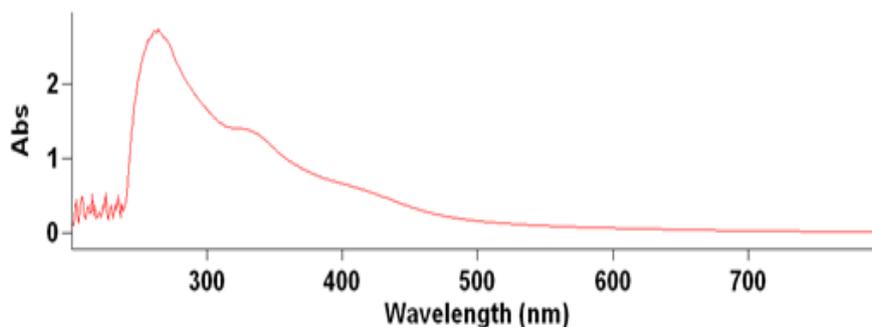
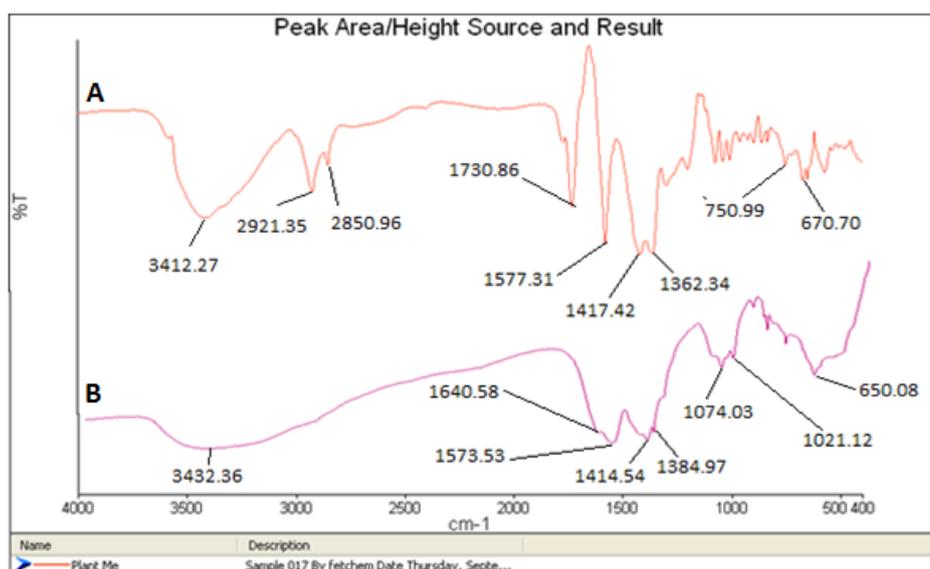


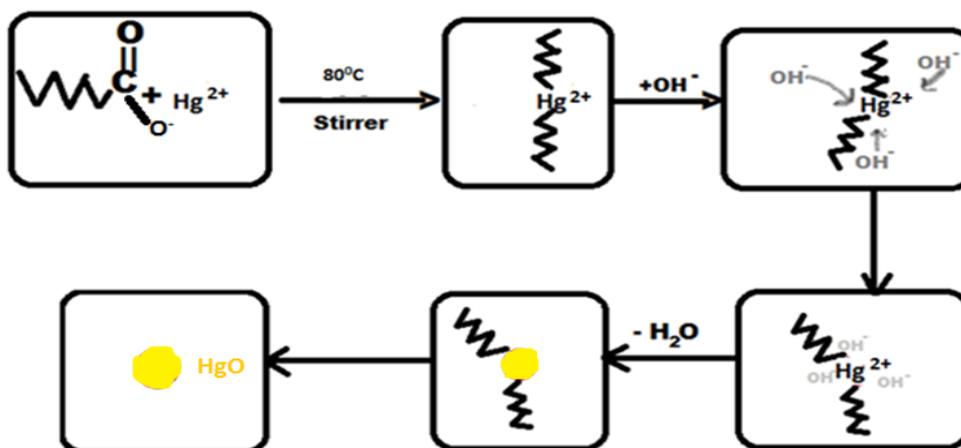
Figure 4: (A) FTIR spectrum of dried aqueous extract of *Callistemon viminalis* flowers. (B) FTIR spectrum of synthesized HgO nanoparticles.



Formation Mechanism of HgO Nano particle

A possible formation mechanism of HgO nanoparticles by this green method based on the report earlier by Akl M. Awwad group¹⁰ has been depicted in figure 5. Mercuric acetate and callistemon viminalis flower extract are in one aqueous phase in the reaction system. The C=O of carboxylic carbonyl group of protein in callistemon viminalis flower chelated with Hg^{+2} to form mercuric protein complex. With heating, OH^- of NaOH would be involved in the reaction. A competition of $\text{COO}^- \dots \text{Hg}^{+2}$ bonds and the formation of $\text{OH}^- \dots \text{Hg}^{+2}$ bonds and a results of formation of mercuric hydroxide, $\text{Hg}(\text{OH})_2$. The formation of mercuric hydroxide form a shell core structure with protein chain of Bottle brush flower extract as core. Mercuric hydroxide in core dehydrated ($-\text{H}_2\text{O}$) forming HgO Nano particle crystals. The shell of protein of Bottle brush flower extract chains attached on HgO surface through chelation of $\text{COO}^- \dots \text{Hg}^{+2}$ at the end of the reaction. HgO Nano particle crystals were capped and stabilized by protein chain of Bottle brush flower extract.

Figure 5: A schematic illustration of the formation mechanism of HgO nanoparticle.



CONCLUSIONS

The present study demonstrates green synthesis of nanosized HgO particles using *Callistemon viminalis*. The *Callistemon viminalis* aqueous flower extract appears to be environmentally friendly, so that this protocol could be used for rapid production of HgO nanoparticles. The size of the nanoparticles can be easily adjusted by using different amounts of extract. In the future, selection of such plants may create a new platform for realizing the potential of herbal medicines in nanoscience for biomedical application. This is a preliminary study of the biological mechanism for biosynthesis of nanoparticles and could be the first step in controlling their size.

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