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RESEARCH ARTICLE

Green synthesis of zinc oxide nanoparticles using whole plant extracts of *Cassia tora* L. and their characterization

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Abstract

Fresh plant extracts of *Cassia tora* were used for green synthesis of metallic zinc oxide nanoparticles (ZnO NPs) in this study. The efficacy of different parts of the plant was tested against UV-Visible spectrophotometry to conclude the synthesis of nanoparticles. Qualitative characterization of ZnO NPs was achieved by observing the strong absorbance peaks between 302-306 nanometers (nm). Initial confirmation of ZnO nanoparticles formation was achieved by gradual color change from colorless to yellow when the plant extracts were challenged with 1mM solution of Zinc Nitrate at room temperature. The characteristic absorbance peak of ZnO NPs from leaves, stem and roots were 302 nm, 306 nm and 304 nm respectively. The investigation confers that *C. tora* could be effectively utilized in biological synthesis of nanoparticles.

Keywords: Zinc oxide nanoparticles, Green synthesis, *Cassia tora*, Characterization

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1. INTRODUCTION

Nanoparticles hold extraordinary and attractive properties due to their small sizes, large surface area, free hanging bonds and superior reactivity (1, 2). There is an exponential growth of global investments in nanotechnology research and nanoscience. The total investments in global market of nanotechnology industries in 2015 were US$ 1880 billion (3). Biological method of nanoparticles synthesis was fulfilled the search of an alternative, cost-effective and environmentally sound method (4, 5). Various reports emphasize that plant based nanoparticles had valuable impact in agriculture, pharmaceuticals, drug delivery and production of other commercial goods (3). Plant extracts mediated synthesis of nanoparticles has been proved advantageous over traditional/ conventional (physical and chemical) methods (6). Use of plant extracts as natural reducing, capping and stabilizing agents have been attained considerable progress and are reported by many authors as an efficient green synthesis method (7, 8). The toxic and high energy consuming methods became unfair in front of biological methods of nano synthesis (9-12). Recently, plants and their extracts based nanoparticles synthesis were considered to be the best techniques because of easy availability, mass production and eco-friendly process (13).

Cassia tora L. belongs to the family Fabaceae, is a small shrub, native to the tropical parts of Asian and African countries. It is commonly known as Sickle Senna, Wild Senna, Sickle Pod, Coffee Pod, Tovara, Chakvad and Ring-worm Plant. It prefers to grow in warm moist soil. The plant is characterized by the pinnate leaves with three pair of opposite leaflets; each leaflet is ovate and oblique at the base. Stem angular, flowers are yellow and axillary, pods are sickle shaped and seeds are brown and rhombohedral in shape. It blooms during rainy season and fruits till winter season (14, 15).

The phytochemical characterization of *C. tora* reveals the presence of bioactive anthraquinones such as aurantio-obtusin, chrysoobtusin, obtusin, chrysophanol, emodin, rhein (16-20), glucosides like alaternin 2-O-β-D-glucopyranoside, naphthopyrone glycoside, ononitol monohydrate and adenosine (17). Phytochemical studies of flowers confer the presence of kaemferol and leucopelargonidin (19). Seeds are reported to contain uridin, quercitrin, toralactune, physcion, emodin, rubrofusarin, palmitic, stearic and succinic acids (20).

The plant has been explored for various biological activities such as antioxidant (21), anti-inflammatory (22), anti-proliferative (23), hypolipidemic (17), anti-diabetic (24), hepatoprotective (25), antimicrobial (26), antigenotoxic, antinociceptive, spasmogenic, immunostimulatory, antifungal, antitumor and antimutagenic activities (15, 27).

Coffee pod has long record of use in Ayurvedic and Chinese systems of medicines. It is used to cure bowel complaints, intestinal dryness, leprosy, bronchitis, cough, ringworm, flatulence, dyspepsia, cardiac disorders, xerophthalmia, conjunctivitis, joint pain, gout and blood pressure (28, 29).

C. tora have already been exploited for the synthesis of nanoparticles. The green synthesized silver nanoparticles from the leaves of *C. tora* were active against amphicillin resistant bacteria such as *Escherichia coli*, *Salmonella* spp. and *Pseudomonas aeruginosa* (30). To the best of our knowledge, this is the first study reporting synthesis of zinc oxide nanoparticles using vegetative part extracts of *Cassia tora* and zinc nitrate.

2. MATERIAL AND METHODS

2.1. Plant collection

Fresh and healthy plants of *Cassia tora* were collected from East Coast region of Puducherry (Pondicherry, India). The photograph of the plant with the aerial parts used to prepare ZnO nanoparticles is shown in Figure 1.

2.2. Preparation of plant extracts

The leaves, stem and root of *C. tora* were procured from mature and disease free plants, washed thrice with distilled water and air-dried for 1 hr at room temperature. Five grams of plant materials were weighed and made into fine pieces using sterile scalpel. To 5g of *C. tora* plant parts, 50 ml of double distilled water was added. Then, the mixture was boiled for 20 min at the temperature of 60^{o}C. The homogenate was filtered using a sterile gauze cloth and used as broth solutions for the synthesis of ZnO nanoparticles.

2.3. Preparation of Zinc Nitrate solution

Aqueous Zinc Nitrate solution was used as precursor for the synthesis of ZnO nanoparticles using *C. tora* plant extacts. One millimolar (1 mM) precursor was prepared by dissolving Zinc Nitrate hexahydrate ($Zn (NO_3)_2 \cdot 6H_2O$) in double distilled water and stored at 4^{o}C for further experiments.

2.4. Preparation of zinc oxide nanoparticles (ZnO NPs)

The ZnO nanoparticles from *C. tora* plant extracts were prepared by previously described method with slight modifications (7). To 5ml of each millimolar concentration of zinc nitrate, 5ml extracts of the different plant parts (leaf, stem and root) was added, in a sterile conical flask. To promote the synthesis of nanoparticles, the conical flasks with reaction medium (broth + precursor) were exposed to the steam water-bath (continuously shaken) till color change from green to yellow and time taken for color change in respective broth solution was recorded (Fig. 1).

After complete addition of extract, the precipitate was separated by high speed centrifugation at 5000 rpm. The bottom settled annealing of the remnants was separated and washed three times with distilled water and the supernatant was discarded. The pellets were diluted with distilled water and stored for further characterization.

2.5. UV-Visible characterization of zinc oxide nanopaticles

To investigate the formation of ZnO NPs, the pellets from different extracts were dispersed in distilled water. The bioreduction of Zn^{+} ions in aqueous broth solutions was monitored by measuring the UV-Visible spectrum of the respective reaction medium. The UV–Visible absorption spectra of the samples were recorded at room temperature in the wavelength range of 200 to 700 nm using a Systronics Double Beam Spectrophotometer (Model 2202, Systronics Ltd.) in diffuse reflectance mode using Zinc nitrate as reference.

3. RESULTS AND DISCUSSION

In general, metalic nanoparticles are conventionally synthesized by wet chemical methods which require toxic and flammable chemicals (30). So far, biological synthesis of nanoparticles were achieved by utilizing plants and algae, diatoms, bacteria, yeast, fungi and human cells (8, 31). But use of plant extracts (green synthesis approaches) were attained great interest in these days (32) and various metals and metal oxide nanoparticles have been successfully synthesized using plant extracts (33, 34). For example, silver nanoparticles from *Couroupita guianensis* (35), titanium oxide nanoparticles from *Catharanthus roseus* (34), gold nanoparticles from *Salvia officinalis* (36) etc.

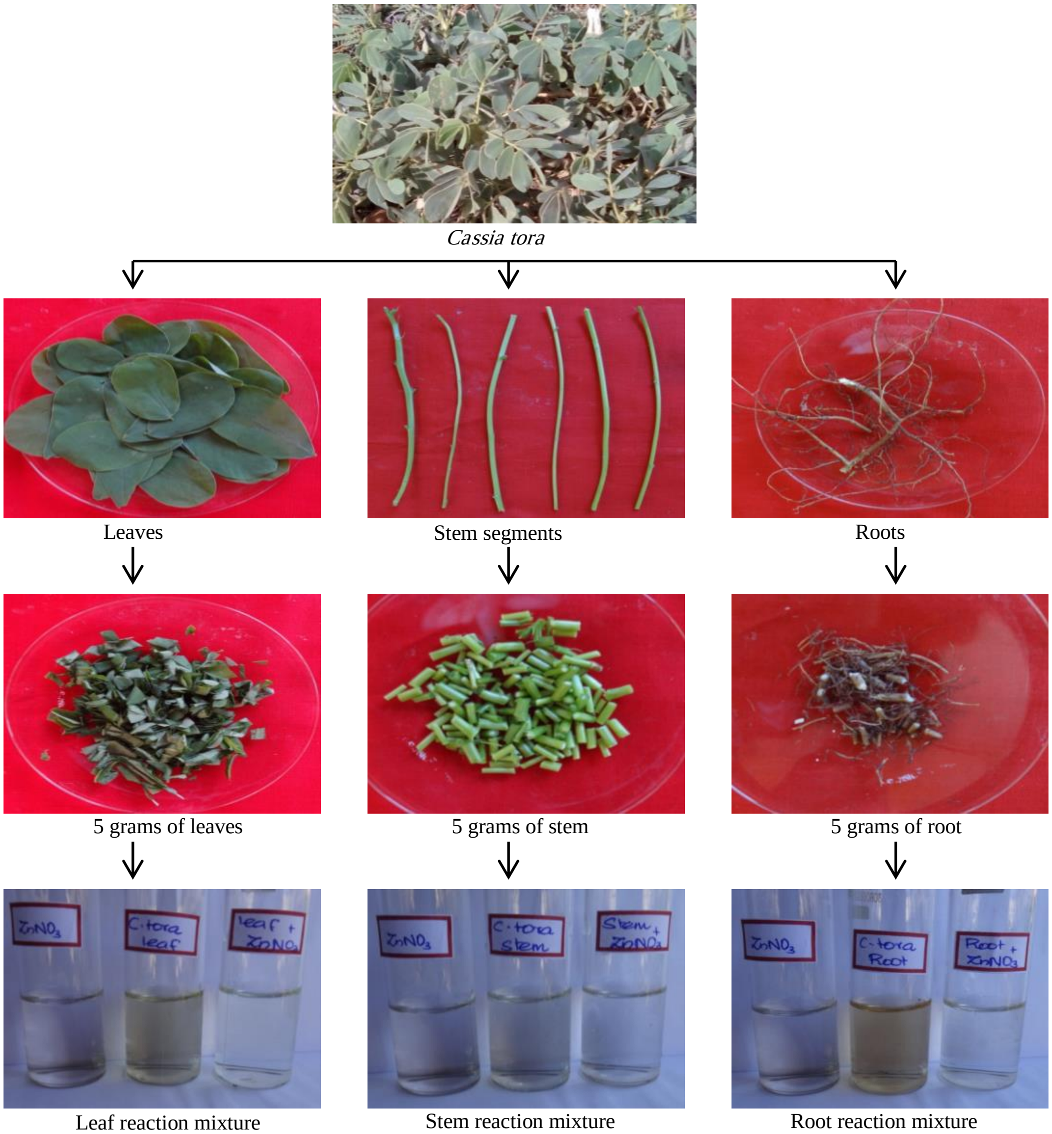

Fig 1. *Cassia tora* plant, leaves, stem segments and roots used in synthesis of ZnO nanoparticles.

ZnO nanoparticles are synthesized by various chemical methods like vapor transport, hydrothermal synthesis, precipitation method etc. (37). So far, various parts of plants were used to synthesize ZnO nanoparticle with assured biological activities. Leaf extracts of *Camellia sinensis* (38), gel of *Aloe barbadensis* (39), flower extract of *Nyctanthes arbor-tristis* (40), stem bark of *Boswellia ovalifoliolata* (41), seeds of *Trachyspermum ammi* (42) and latex of *Calotropis procera* (43). The present study utilized the vegetative parts of *Cassia tora* for the synthesis of ZnO nanoparticles.

The colorless zinc nitrate solution was turned to yellow, indicated the formation of ZnO nanoparticles. The cell free extracts of *C. tora* and zinc nitrate solution was exposed to UV visible wavelengths and the absorbance was recorded. Based on the surface plasmon resonance (SPR), the ZnO nanoparticles showed the characteristic SPR at the wavelengths between the ranges of 302-306 nm. Figure 2 showed the absorbance peaks obtained from UV- visible double beam spectroscopy, which strongly suggests that *C. tora* could be a better biological source in synthesis of ZnO nanoparticles. The aqueous reaction mixture of leaf showed maximum absorption peak at 302 nm, stem reaction mixture at 306 nm and root reaction mixture at 304 nm (Fig. 2).

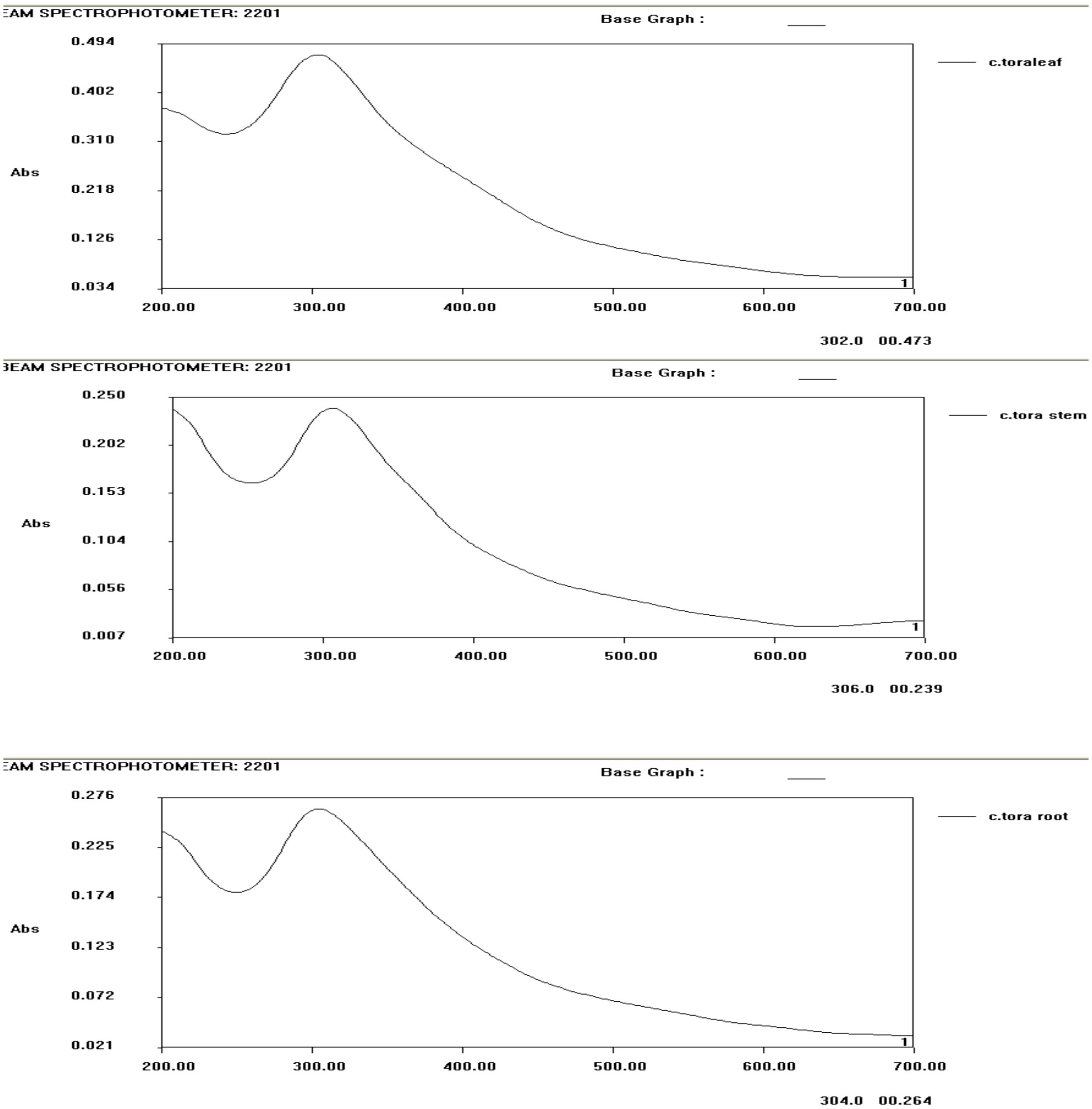

Fig 2. UV-Visible spectral absorption peaks of ZnO nanoparticles from leaf, stem and root reaction media.

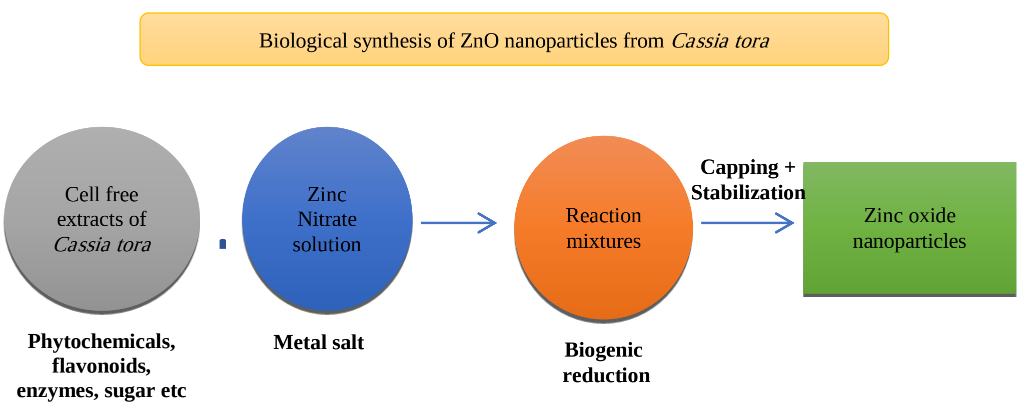

Fig. 3. Schematic representation of ZnO nanoparticles synthesis.

Aqueous extracts of *C. tora* plant was reported to contain flavonoids, terpenoids, saponin, tannin, phenols, amino acids, proteins, anthraquinones, glycosides and steroids (44). These phytochemicals may act as capping and stabilizing agents of ZnO nanoparticles formation when challenged with zinc nitrate solution (5, 7) (Fig. 3). The present report could be further utilized for the synthesis of ZnO nanoparticles from *C. tora* plant extracts in the formulation of various products for human welfare.

4. Conclusion

The biosynthesis of zinc oxide nanoparticles using vegetative parts of *Cassia tora* has been reported. It is simple, cost-effective, rapid and eco-friendly way to synthesize zinc oxide nanoparticles and capable of synthesizing within few hours at room temperature. In this method, plant extracts played as capping agents. The synthesized nanoparticles may be further explored for preparation of nano medicines and other products.

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