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RESEARCH ARTICLE

Tridax procumbens L. Mediated Preparation of Zinc Oxide Nanoparticles and their Characterization

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Abstract

In the production of nanoparticles, the bio-reduction properties of plant extracts are acknowledged worldwide to reduce the harmful effects of physical and chemical methods of synthesis of nano-scale metal particles. The present study states a green approach for the synthesis of zinc oxide nanoparticles employing aqueous extracts of leaf, stem, root and inflorescence of *Tridax procumbens*. Zinc nitrate hexahydrate was used as precursor. Various parameters such as temperature, volume of precursor and reducing agents were optimized for maximal synthesis of zinc oxide nanoparticles. The synthesized nanoparticles in aqueous solutions were further confirmed by characterizing the reaction mixtures using the UV–visible spectroscopy. Leaf, root and inflorescence reaction mixtures presented strong absorption peak at 302 nm and the stem reaction mixture resulted at 300 nm. The nanoparticles were observed to be stable after 2 months. The present study reports that the whole plant *Tridax procumbens.* could be used in the synthesis of potential ZnO nanoparticles.

Keywords: *Tridax procumbens*, ZnO nanoparticles, Precursor, Metal oxide, UV- Visible spectrophotometer.

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1. INTRODUCTION

The particulate nanomaterials are used by various industries in extensive series of emerging consumer products (1). Among the metallic nanoparticles used, Zinc oxide nanoparticles (ZnO NPs) are reported to possess wide range of applications such as biofertilizers, food items, pigments, personal care products, semiconductors, ceramics industry, paints, batteries etc. (2).

The positive effects of zinc oxide nanoparticles on plant growth and development were evidenced in number of species. Plant extract mediated zinc oxide nanoparticles were reported to have potential applications in seed germination of *Arachis hypogea* (3), Cucumber (4), Soybean (5), Onion (6), *Sesamum indicum* (7) and *Brassica nigra* (8). ZnO nanoparticles were reported to increase the biomass accumulation and gum production in *Cyamopsis tetragonoloba* (9), and to enhance shoot and root length in *Vigna radiata* and *Cicer arietinum* (10).

The use of various plant parts in reduction and stabilization of zinc oxide nanoparticles is rapidly increasing due to its eco-friendly and non-hazardous biosynthetic processes (11). The plant extracts are reported to mediate reduction and stabilization of metallic ions by combination of various biomolecules present in the plant system, including proteins, enzymes, polysaccharides, alkaloids, tannins, phenolics, saponins, terpenoids, vitamins etc. (12, 13). A large number of plants species are reported to assist in the synthesis of zinc oxide nanoparticles such as *Morinda pubescens* (14), *Hibiscus subdariffa* (15), *Moringa oleifera* (16), *Adhatoda vasica* (17) *and Leucas aspera* (18).

Tridax procumbens L. (family Asteraceae) is a perennial creeper herb, native to the tropical America but it is growing worldwide. It is popularly known as ‘Ghamra’ and ‘coat buttons’. It prefers to grow in tropical sunny dry habitats, coarse textured soils and in open fields. Leaves are simple, short, opposite, hairy, lanceolate to ovate in shape, toothed margin and measured 5-7 cm in length. Stem is green, climbing, branched, hairy and the roots arise from the nodes. The capitulum inflorescence possesses tubular and yellow colored ray florets and disc florets with basal placentation. Fruits are hard achenes with feathery stiff hairs and pappus at one end. Seeds have pendulous embryo without endosperm. The flowering and fruiting is observed throughout the year (19-21).

The phytochemical characterization of this plant reveals the presence of alkaloids, flavonoids, carotenoids, fumaric acid, β-sitisterol, luteolin, glucoluteolin, n-hexane, tannin, quercitin, oxoester, lauric acid, myristic, palmitic, arachidic, linoleic acid and minerals such as sodium, potassium and calcium (22-24). Leaves are reported to contain linolenic acid and water soluble polysaccharide (WSTP-IA and WSTP-IB) (25). *Tridax procumbens* exhibits various biological activities, such as antidiabetic, anti-hepatotoxic, antioxidant, anti-inflammatory, analgesic, wound-healing, hepatoprotective, antimicrobial, immunomodulatory and anti-cancerous properties (20, 26-29). Traditionally the plant is used to treat malaria, blood pressure, dysentery, diarrhoea, stomach-ache and headache (20).

The biological synthesis of ZnO nanoparticle using plant extracts is environmentally benevolent, from which safer and non-hazardous bio-transformations are possible. Therefore, the present investigation is aimed to use the various extracts of *T. procumbens* for the synthesis of ZnO nanoparticles at room temperature.

2. Materials and Methods

2.1 Materials

Zinc Nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$] was procured from Merck (Mumbai, India). The morphologically well grown *Tridax procumbens* plants were collected during the months of June 2016 – December 2016 from the Coromandel Coast of Puducherry, India. The plant parts such as fresh leaves, stems, roots and inflorescence (Fig. 1A to 4A) were separated for the synthesis of ZnO nanoparticles.

2.2 Preparation of plant extracts

All the plant materials were carefully washed with double distilled water and shade dried for 2 hrs. Ten grams of each and every material were finely chopped (Fig. 2A to 2D) using sterile scalpel and added to sterilized conical flasks containing 100 ml of Milli-Q water and boiled for 10 min. Thereafter the extracts were filtered through Whatman filter paper (90 mm) and used as a broth solution.

Fig. 1. Various parts of *Tridax procumbens* used for the synthesis of ZnO Nanoparticles; **A-** Leaves, **B-** Stem segments, **C-** Roots, **D-** Inflorescence

Fig. 2. Finely cut plant materials; **2A-** Ten grams of chopped leaves, **2B-** Stem segments, **2C-** Root segments and **2D-** Inflorescence

2.3 Preparation of precursor

Aqueous solution of 1mM (milli molar) Zinc Nitrate hexahydrate [$Zn(NO_3)_2.6H_2O$] (Merck, Mumbai) was used as a precursor for the synthesize zinc oxide nanoparticles from *T. procumbens*.

2.4 Biosynthesis of ZnO NPs

One milliliter (ml) of freshly prepared 1mM Zinc nitrate solution was added to the plant extracts at room temperature for the synthesis of Zinc oxide nanoparticles. To observe the visual changes during the reduction of nanoparticles, three boiling tubes were taken, first one containing 10 ml of 1mM Zinc nitrate solution served as control and the second one containing 10 ml of plant extract and the third tube was presented with 9 ml of precursor solution and 1ml of plant extract as a reaction mixture (Fig. 3A to 3D). The time duration taken for the changes in the intensity of color of the reaction mixtures were recorded.

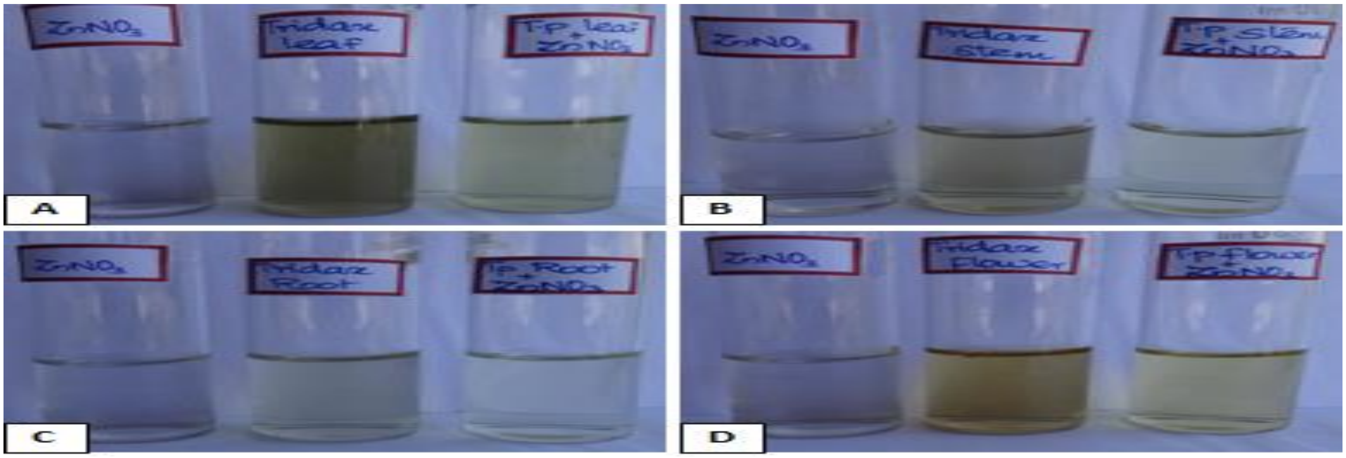

Fig. 3 *T. procumbens* mediated synthesis of ZnO nanoparticles**; 3A-** Precursor (10ml), leaf extract (10ml) and leaf reaction medium (1ml leaf extract + 9ml of precursor), **3B-** Stem reaction medium, **3C -** Root reaction medium, **3D -** Inflorescence reaction medium

2.5 Characterization of ZnO NPs

The reaction mixtures of leaf, stem, roots and Inflorescence were centrifuged at 5000 rpm for 20 min to separate the supernatant from the pellet, the later one was used for further study. The pellets were dissolved in Milli-Q water and examined through spectrophotometric analysis. The synthesis of zinc oxide nanoparticles were confirmed and characterized by UV-Visible spectrophotometer (Systronics Double Beam Spectrophotometer, Model 2202, Systronics Ltd.). The initial calibration of spectrophotometer was done using precursor solution. The UV-Vis absorption spectra of the zinc colloids from various parts of the plant were confirmed by using wave length scan between 200nm and 700nm.

3. Results and Discussion

3.1 Visual examination

A pale yellowish color was observed in the reaction mixtures upon addition of 1 ml of *T. procumbens* leaf and stem extract to 9 ml of zinc nitrate solution, which gradually changed to dark yellow on incubating the reaction mixtures at room temperature for 1hr. Initially no color change was observed in the roots and inflorescence reaction mixtures, which was changed to pale yellow on subjecting to heating at 40-60ºC. The changes in color indicated the reduction reaction of zinc ions. After addition of leaf and stem extract with the precursor, immediate color change was observed. The biosynthesis of ZnO nanoparticles from plants extracts is an enzymatic process (9). Aerial parts of *T. procumbens* were reported to be rich in proteins/ amino acids, polysaccharides and minerals. This indicates that the proteins/ amino acids in the leaf and stem extracts were acted as reducing as well as stabilizing agents, which brought the immediate color changes in respective reaction mixtures. The biomolecules present in the plant parts are responsible for the time duration and change of color for the synthesis of zinc oxide nanoparticles (17).

3.2 UV-visible characterization of ZnO NPs

This plant has already been stepped in the field of nanoparticles synthesis. Bhati-Kushwaha (30) reported the biogenic production of silver nanoparticles from the leaf and stem extracts of *T. procumbens*. These silver nanoparticles were exhibited latent antimicrobial activity against *Escherichia coli, Vibrio cholerae, Salmonella* sp., *Shigella* sp., *Aspergillus niger* and *Aspergillus flavus* (31). Water soluble carbohydrates from the leaf extract of *T. procumbens* are reported to mediate the synthesis of copper nanoparticles which showed noteworthy antibacterial activity against *Escherichia coli* (32). The silver nanoparticles synthesized from the leaves of *T. procumbens* exhibits haemostatic activity by promoting blood clotting (33).

For further confirm of synthesis of ZnO NPs from various extracts of *T. procumbens*, the reaction mixtures were examined for UV-visible spectrophotometric analysis. Metallic nanoparticles exhibit surface plasmon resonance absorption in the UV-Visible region (34). The UV-visible spectrum of zinc nanoparticle colloidal solutions synthesized from *T. procumbens* leaves, roots and inflorescence extracts presented absorbance peak at 302 nm (Fig. 4A-4D). The stem reaction mixture exhibited absorption peak at 300 nm. It indicates that the biomolecules present in the plant at similar fractions may induce the formation of zinc oxide nanopaticles from zinc nitrate. The synthesized nanoparticles were stable for 2 months. Stability of ZnO NPs was reported due to the presence of secondary metabolites in the plants (35).

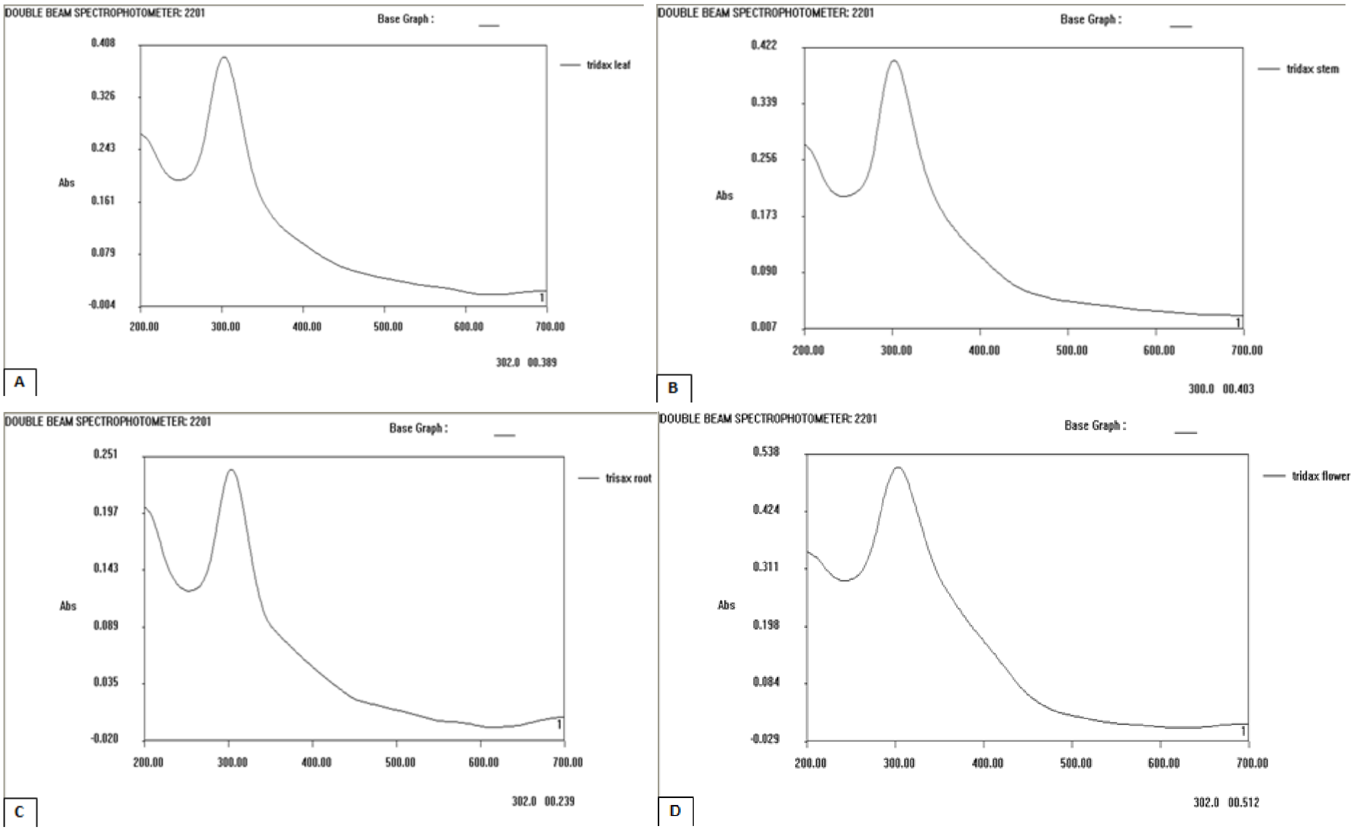

Fig. 4. UV-Visible characterization of ZnO nanoparticles; **4A** - UV-Visible absorption spectrum of leaf reaction medium. **4B** - UV-Visible absorption spectrum of stem reaction medium. **4C**- UV-Visible absorption spectrum of root reaction medium. **4D** - UV-Visible absorption spectrum of inflorescence reaction medium.

This plant has been reported to possess significant biological activities which are useful to mankind. The ZnO nanoparticles could be explored for the formulation of new medicines from *T. procumbens*.

4. CONCLUSION

In the present study, zinc oxide nanoparticles were synthesized using aqueous leaf, stem, root and inflorescence extract of *Tridax procumbens*, a tropical ethnomedicinal creeping herb. The various conditions for the synthesis of ZnO NPs were optimized and characterized using UV- visible spectroscopy. This report may open a new door to the further exploration of *Tridax* mediated ZnO NPs in the formulation of medicines and cosmetics.

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