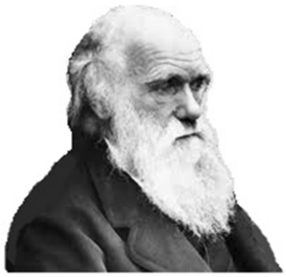
Available online at www.worldnewsnaturalsciences.com



World News of Natural Sciences

An International Scientific Journal

WNOFNS 23 (2019) 200-210 EISSN 2543-5426

Green synthesis of zinc oxide nanoparticles from aqueous extracts of *Sesamum indicum* L. and their characterization

M. Manokari[1,*], R. Latha[2], S. Priyadharshini[2], Raj M. Cokul[2], Puneet Beniwal[3], M. S. Shekhawat[2]

[1]Siddha Medicinal Plants Garden, Mettur, (Central Council for Research in Siddha), TN - 636 401, India

[2]Department of Botany, K.M. Centre for Post Graduate Studies, Puducherry 605008, India

[3]Centre for Biotechnology, Maharshi Dayanand University, Rohtak - 124 001, India

***E-mail address: manokari01@gmail.com**

ABSTRACT

Green synthesis of Zinc oxide nanoparticles (ZnO-NPs) is a novel and non-toxic method as compared to the hazardous conventional physical and chemical methods. Herein, we report production of ZnO-NPs for the first time using whole vegetative parts of *Sesamum indicum* L. The aqueous extracts of various parts of *S. indicum* were used to synthesize nanoparticles in this study. The synthesized nanoparticles were evaluated using UV-visible spectroscopy for confirmation and characterization. The maximum UV-visible spectral absorption peaks were observed from 293 to 296 nm wavelengths. Leaf and stem reaction mixtures exhibited the sharpest absorption peaks of all the variations at 293 nm and root at 296 nm. This study leads to the development of cost-effective ZnO-NPs synthesis with a possible further exploration to serve mankind.

***Keywords*:** Biosynthesis, Characterization, Plant Extracts, *Sesamum indicum*, Zinc Oxide Nanoparticles

1. INTRODUCTION

Recently, preferences have been laid on herbs based nanoparticles synthesis due to their eco-friendly, non-toxic and reduced use of chemicals, as compared to the conventional (physical and chemical) methods [1, 2]. Nanoparticles synthesized through chemical methods

(Received 02 February 2019; Accepted 19 February 2019; Date of Publication 20 February 2019)

are reported to absorb the toxic chemicals on their surface, hence becoming noxious in medical applications [3, 4]. But the green-route synthesis method of nanoparticles from plants proved safe with no side effects on living systems [5, 6].

Zinc oxide (ZnO) is a wurtzite n-type semiconducting material with unique electronic and photonic properties. At room temperature, ZnO exerts wide direct band gap (3.37 eV) and a high exciton binding energy (60 meV) [7, 8]. Zinc oxide NPs are extensively exploited in pharmaceutical and cosmetic industries due to their astonishing properties, such as compatibility with human skin, non-toxic, self-cleansing, UV-blocker in sunscreens, efficient resisting capacity against microorganisms, etc. [9-11].

ZnO-NPs are successfully studied to enhance growth in food crops, such as *Triticum aestivum*, *Pennisetum americanum*, *Cyamopsis tetragonoloba*, *Arachis hypogea*, *Solanum lycopersicum*, *Cucumis sativus*, *Vigna radiata*, *Cicer arietinum*, *Zea mays*, *Raphanus sativus*, *Allium cepa*, etc. [12-16].

Various biological activities of plant extracts mediated ZnO-NPs were reported, viz. ZnO NPs synthesized using *Limonia acidissima* leaf extracts are active against *Mycobacterium tuberculosis* [17]. Antimicrobial activity of *Emblica officinalis* mediated ZnO-NPs reported by Anbukkarasi *et al*. [18].

Zinc oxide NPs from *Plectranthus ambonicus* leaf extracts found to inhibit the growth of human pathogenic bacteria and mosquito larvae [19]. *Passiflora caerulea* leaf based ZnO-NPs proved against urinary tract infecting pathogens [20]. Micro-scale and nano-scale formulations of ZnO-NPs synthesized from herbal extracts are investigated for biofertilizer, antibacterial [21], antifungal [22], cytotoxic [23], larvicidal [19], photocatalytic [24], anti-diabetic [25], antiplasmodial [19], genotoxic and anticancer [26, 16] activities (**Fig. 1**).

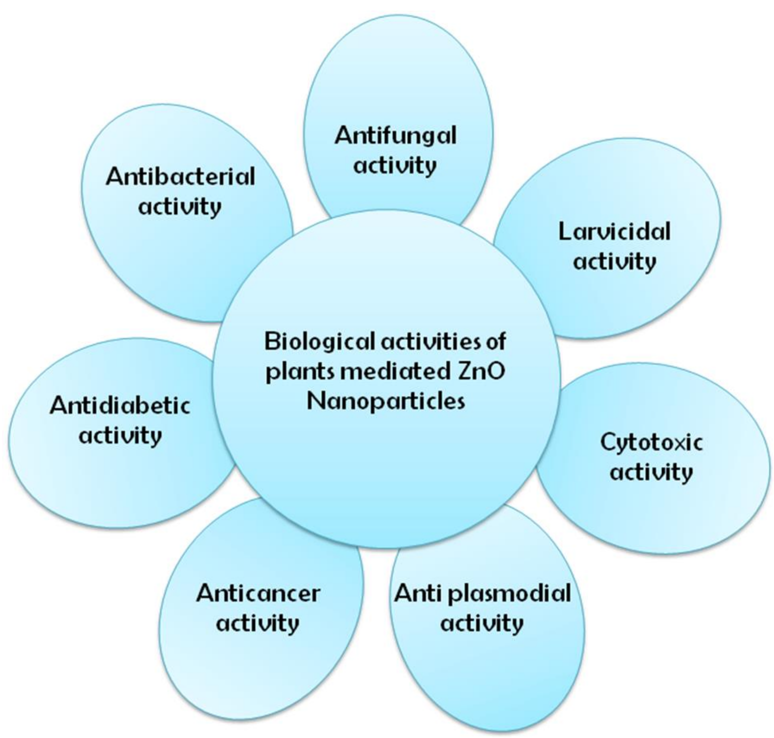


Fig. 1. Different biological activities of herbal extracts based ZnO Nanoparticles

Sesamum indicum L. (Queen of oilseeds) is an annual plant, belonging to the family Pedaliaceae and distributed throughout the tropics [27]. This plant has been explored for various pharmacological properties, such as antipyretic, anti-inflammatory, anti-oxidant, anti-microbial, anti-hypertensive, antinociceptive, wound healing, and anticancer properties [28-31]. The whole plant is used to treat various diseases in the Indian traditional systems of medicines [32]. Phytochemistry of *S. indicum* leaves reveals the presence of lignans, iridoids, lamalbid, sesamoside, shanzhiside methyl ester, cistanoside F, chlorogenic acid, pedalitin-6-O-laminaribioside, pedaliin, isoacteoside, pedalitin, and martynoside [33].

In the present report, an attempt was made to search the potentiality of *S. indicum* plant extracts in biogenesis of ZnO nanoparticles at room temperature.

2. MATERIALS AND METHODS

2. 1. Plant collection

The plant was identified using standard flora [34]. The fresh green leaves, stem and roots of *S. indicum* were harvested from the agricultural field at Puducherry (11.9416° N, 79.8083° E), South India, during the months of October to December, 2018. The collected materials were washed with distilled water and shade dried at room temperature for further use (**Figs. 2A-C**).

2. 2. Preparation of the plant extract

Fig. 2. Various parts of *S. indicum* (A) Leaves, (B) Stem pieces and (C) Roots.
Fig. 3. Choped plant parts (A) Leaves, (B) Stem pieces and (C) Roots.

Five gram of fresh materials (leaf, stem, and root) were washed with running tap water and then with distilled water. The plant parts were then chopped (**Figs. 3A-C**) and boiled in 250 ml Erlenmeyer flask containing 50 mL distilled water at 70 °C for 10 min. The aqueous extracts were then cooled to room temperature, filtered through Whatman number-1 filter paper, and the filtrate was stored at 4 °C for further experimental use.

2. 3. Synthesis of ZnO-NPs and optimization of parameters

Zinc Nitrate hexahydrate [$Zn(NO_3)_2 \cdot 6H_2O$], purchased from Thermo Fisher Scientific India Pvt. Ltd. (Mumbai), was used as precursor to synthesize ZnO-NPs. Five mL of 1mM Zinc Nitrate solution was added to 5 mL of plant extracts and kept on stirrer for one hour and the color of the reaction mixture was observed after 1 hour. Yellow color appeared after the incubation time confirmed the synthesis of ZnO NPs. The precipitate was separated from the reaction solution by centrifugation at 10000 rpm for 15 min and the pellet was collected. The pellet was dried using a hot air oven operating at 60 °C for 4 h and used for further studies.

2. 4. UV–Visible spectroscopic characterization of biosynthesized ZnO-NPs

Optical properties of ZnO-NPs were characterized based on UV absorption spectra with the wavelength range between 200 nm to 700 nm. For UV–Visible spectroscopy, the resultant pellet from each of the reaction mixture was re-suspended in distilled water and spectrum scans were performed using Systronics Double Beam Spectrophotometer (Model 2202, Systronics Ltd.) in diffuse reflectance mode using Zinc nitrate as reference (**Fig. 4**).

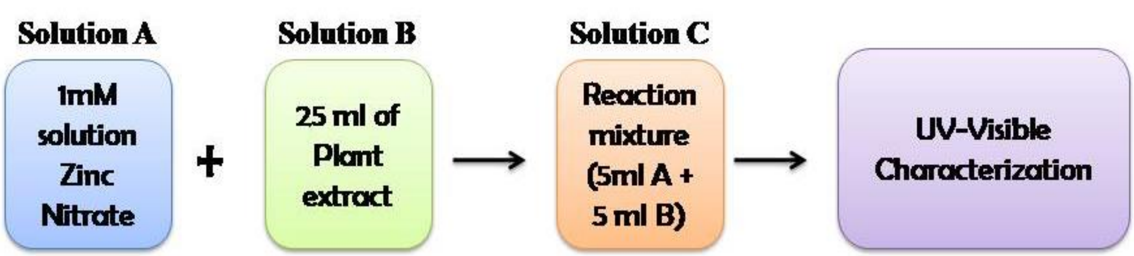


Fig. 4. Schematic representation of synthesis of ZnO-NPs.

3. RESULTS AND DISCUSSION

The parameters for phytosynthesis of ZnO-NPs from *S. indicum* were optimized in the present study. Zinc nitrate is generally most commonly used substrate for the biosynthesis of ZnO nanoparticles. Application of Zinc nitrate in synthesis of ZnO-NPs were reported by Diallo *et al*. [35] in *Aspalathus linearis*, Ravindran *et al*. [36] in *Duranta erecta*, Sutradhar and Saha [37] in *Lycopersicon esculentum*, Manokari and Shekhawat [38] in *Cassia tora*, etc.

3. 1. Visual observation

Zinc oxide is considered as a potential material to operate in the visible spectra and close to ultraviolet spectral region [39]. Being a preliminary test for nanoparticles synthesis, visual color change in the reaction mixture was observed (Fig. 4) to confirm the synthesis of ZnO-

NPs synthesized using freshly prepared aqueous extract of plant materials. ZnO-NPs have reported to posses superior optical properties [20]. Color change from white, pale yellow to dark yellow confirmed the synthesis of ZnO-NPs from *S. indicum* at initial stage.

3. 2. UV-visible spectral analysis

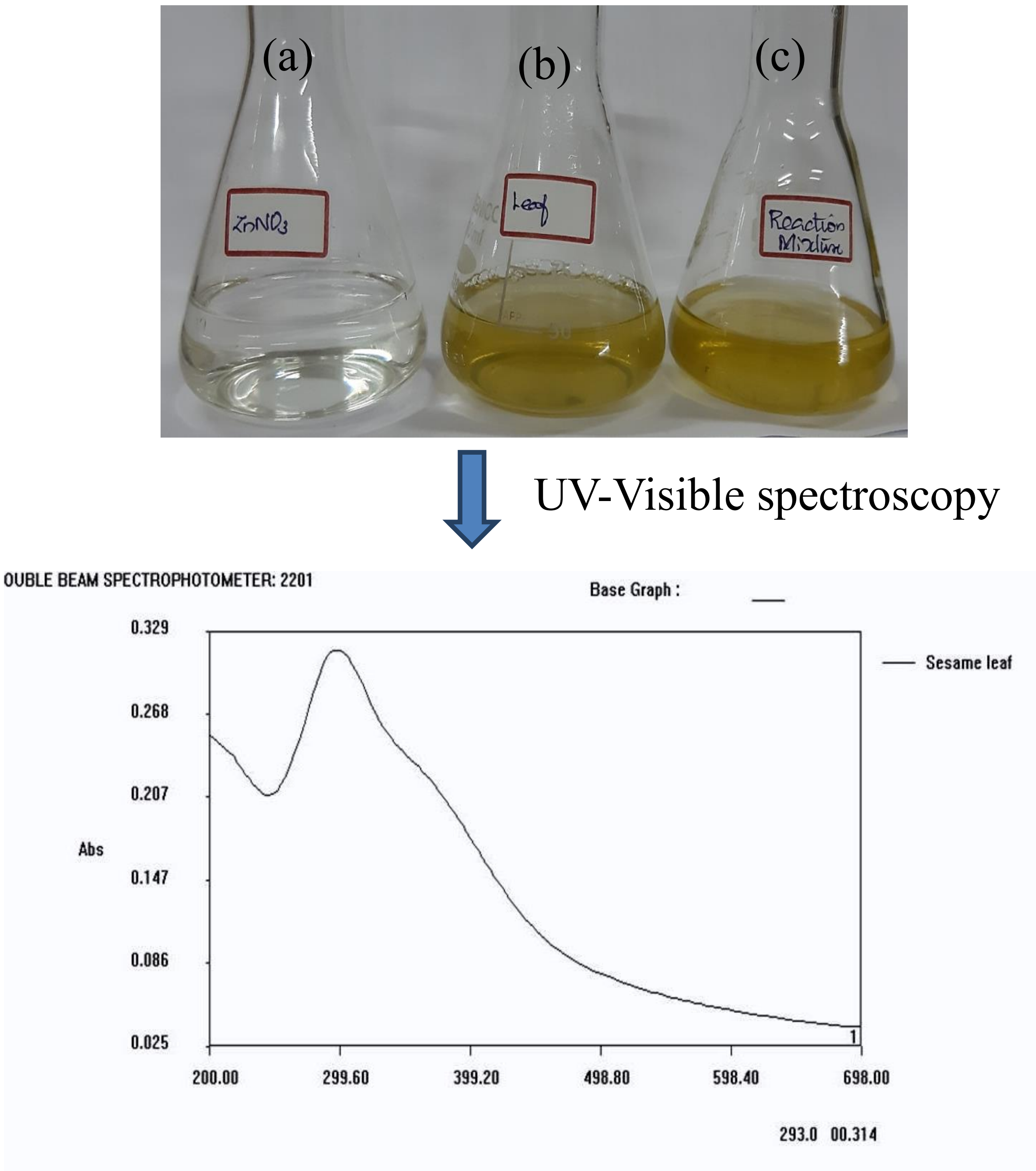


Fig. 5. Visual observation of ZnO NPs synthesis (a) Zinc Nitrate solution (b) *S. indicum* leaf extract (c) final color change in reaction mixture (d) UV-Vis spectrum of ZnO-NPs synthesized by leaf extract of *S. indicum*.

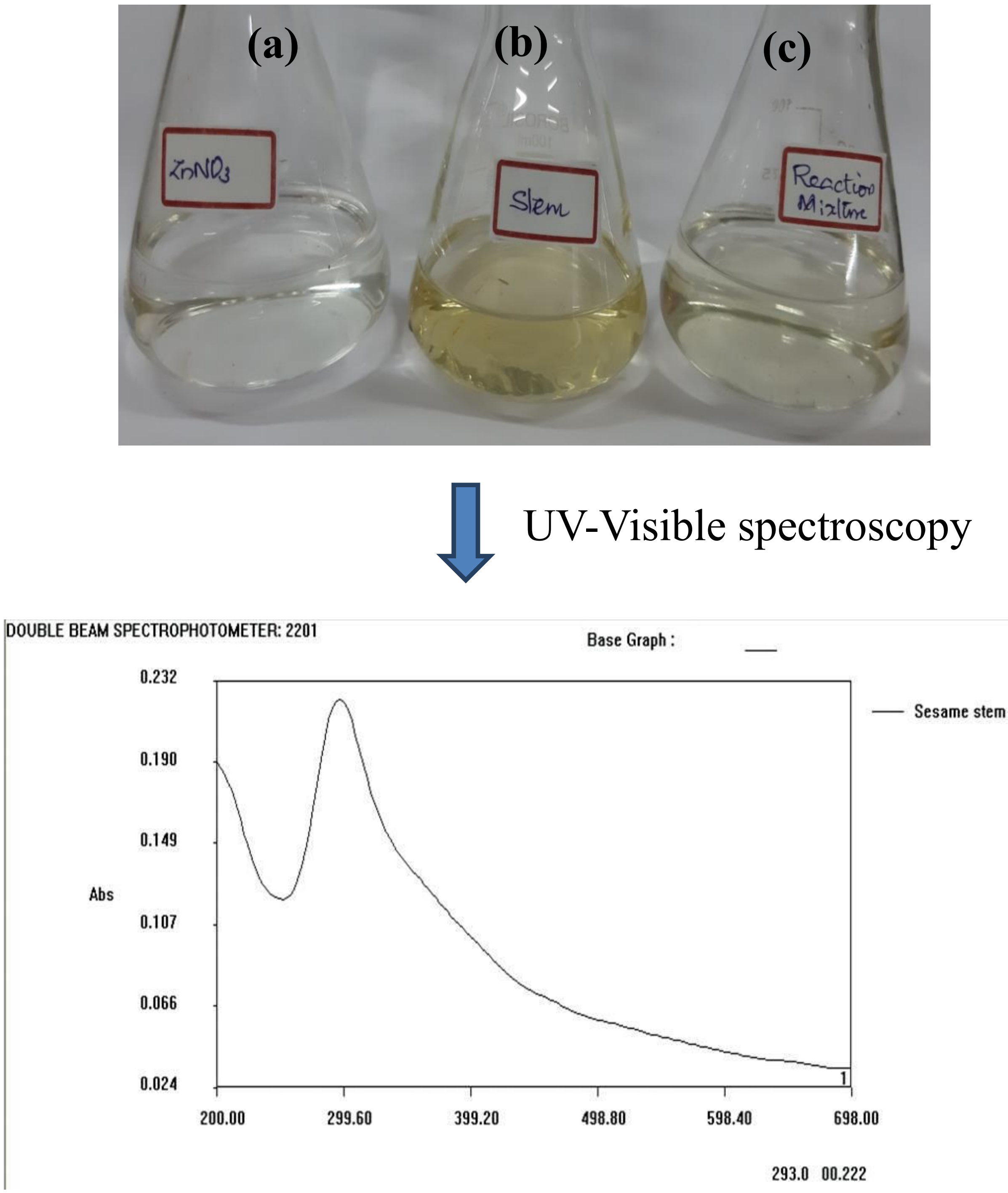


Fig. 6. Visual observation of ZnO NPs synthesis (a) Zinc Nitrate solution (b) *S. indicum* stem extract (c) final color change in reaction mixture (d) UV-Vis spectrum of ZnO-NPs synthesized by stem extract of *S. indicum*.

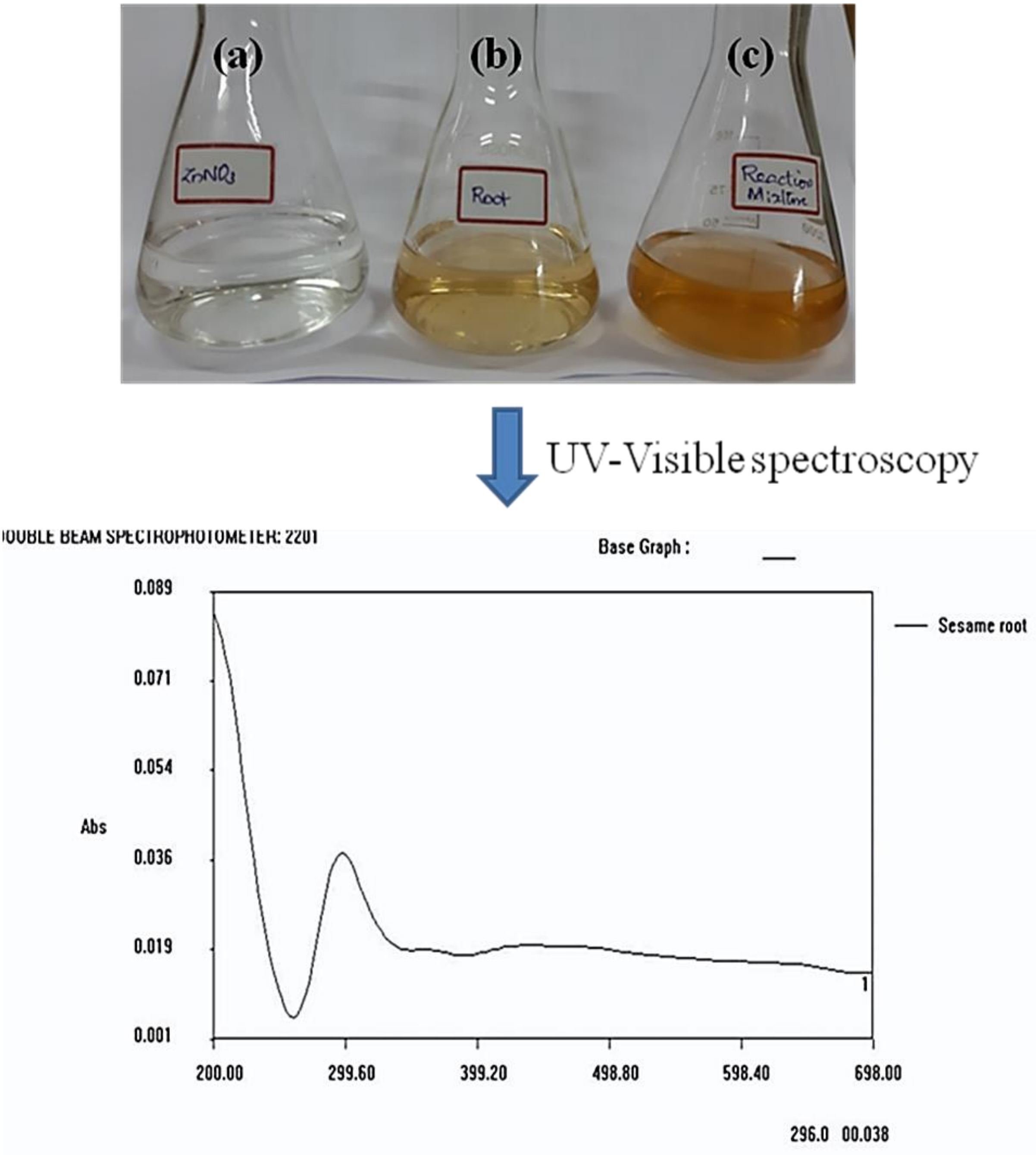


Fig. 7. Visual observation of ZnO NPs synthesis (a) Zinc Nitrate solution (b) *S. indicum* root extract (c) final color change in reaction mixture (d) UV-Vis spectrum of ZnO NPs synthesized by root extract of *S. indicum*.

UV-visible spectroscopy is a confirmatory method of ZnO-NPs synthesis [20]. The reaction mixtures (pale yellow to yellow colored samples) were subjected to scan through UV-Spectrophotometer in the range of 200-700 nm. The conducting electrons present in the reaction mixtures oscillate at a certain wavelength between the selected ranges (200-700nm) as a result of surface plasmon resonance (SPR) effect. **Figures 5-7** represent the UV-visible spectra of freshly prepared ZnO-NPs from leaf, stem, and root extracts. Various peaks were observed with the respective reaction mixtures, ranging from 293 to 296. The absorption peak obtained at 293 nm clearly demonstrates the presence of ZnO-NPs in the leaf and stem reaction mixture (Figs. 5 and 6). Initial peak obtained at the range of 260 nm and further increased due to oscillation of more electrons after 1 h which described the synthesis of ZnO-NPs. After 1 hour, the peaks were observed stable, which indicated the formation of nanoparticles at room temperature (Fig. 7).

Ultra-Violate spectrum has been reported to detect conjugated unsaturated chromophores (polyenes, α, β-unsaturated ketones and aromatic compounds) and flavones. The UV spectrum represents the total chromophores from polyfunctional secondary metabolites of plant extracts [40, 41]. The phytochemicals in the plant extracts help in the synthesis of metal oxide nanoparticle by inducing oxidation and reduction reaction [42]. Such biosynthesized nanoparticles exhibit various shape, size, more stable and biocompatible with no environmental adverse effects and the rate of synthesis is also faster as compared to the use of other organism [43-45].

4. CONCLUSIONS

In the present study, the ZnO-NPs were synthesized using *S. indicum* plant parts aqueous extracts. The biogenic process is an eco-friendly and non-toxic procedure. Presence of functional groups of secondary metabolites in the plant extracts, mediated the synthesis of Zinc metal oxide nanoparticle. As a preliminary confirmation, visual observance of yellow color in the reaction mixture was obtained. The rapid synthesis of ZnO-NPs was confirmed and measured using the UV-Visible spectroscopy at 293-296 nm. Therefore, it can be concluded that it is an efficient and simple method for the green synthesis of multifunctional ZnO-NPs using aqueous extracts of *S. indicum* vegetative parts. Zinc oxide, being a safe food additive, in this study could make better use of ZnO nanoparticles in biofortification, cosmetic production, agricultural practices, etc.

References

[1] Ramesh P., Rajendran A., and Meenakshisundaram M. Green synthesis of zinc oxide nanoparticles using flower extract Cassia auriculata. *J Nanosci Nanotechnol* 1 (2014) 41-45

[2] Dobrucka R. and Dugaszewska J. Biosynthesis and antibacterial activity of ZnO nanoparticles using Trifolium pratense flower Extract. *Saudi J Biol Sci* 23 (2016) 517-523

[3] Parashar U.K., Saxena P.S., and Srivastava A. Bioinspired synthesis of silver nanoparticles. *Dig. J. Nanomater. Biostruct* 4 (2009) 159-166

[4] Fouda A., Hassan S.E., Salem S.S., and Shaheen T.I. In-vitro cytotoxicity, antibacterial, and UV- protection properties of the biosynthesized zinc oxide nanoparticles for medical textile applications. *Microbial Pathogenesis,* 125 (2018) 252-261

[5] Begum N.A., Mondal S., Basu S., Laskar R.A., and Mandal D. Biogenic synthesis of Au and Ag nanoparticles using aqueous solution of black tea leaf extracts. *Colloids Surf. B. Biointerf.* 71 (2009) 113-118

[6] Matinise N., Fuku X.G., Kaviyarasu K., Mayedwa N., and Maaza M. ZnO nanoparticles via Moringa oleifera green synthesis: Physical properties & mechanism of formation. *Applied Surface Science*, 406 (2017) 339-347

[7] Calestani D., Zha M.Z., Mosca R., Zappettini A., Carotta M.C., Di Natale, V., and Zanotti L. Growth of ZnO tetrapods for nanostructure-based gas sensors. *Sens. Actuators B*, 144 (2010) 472-478

[8] Geetha M.S., Nagabhushana H., and Shivananjaiah H.N. Green mediated synthesis and characterization of ZnO nanoparticles using Euphorbia Jatropha latex as reducing agent. *Journal of Science: Advanced Materials and Devices,* 1 (2016) 301-310

[9] Padmavathy N. and Vijayaraghavan R.R. Enhanced bioactivity of ZnO nanoparticles-an antimicrobial study. *Sci Technol Adv Mater* 9 (2008) 035-040

[10] Krishnakumar T., Jayaprakash R., Pinna N., Singh V., Mehta B., and Phani A. Microwave-assisted synthesis and characterization of flower shaped zinc oxide nanostructures, *Mater. Lett.* 63 (2009) 242-245

[11] Shirgholami A., Nazari, and Mirjalili M. Statistical optimization of self-cleaning technology and color reduction in wool fabric by nano zinc oxide and eco-friendly cross-linker, *Clean. Technol. Environ. Policy* 17 (2015) 905-919

[12] Raliya R. and Tarafdar J.C. ZnO nanoparticle biosynthesis and its effect on phosphorous-mobilizing enzyme secretion and gum contents in clusterbean (Cyamopsis tetragonoloba L.). *Agric Res* 2 (2013) 48-57

[13] Prasad T.N.V.K.V., Sudhakar P., Sreenivasulu Y., Latha P., Munaswamy V., Raja Reddy K., Sreeprasad T.S., Sajanlal P.R., and Pradeep T. Effect of nanoscale zinc oxide particles on the germination, growth and yield of peanut. *J Plant Nutr* 35 (2012) 905-927

[14] Zhao L.J., Peralta-Videa J.R., Rico C.M., Hernandez-Viezcas J.A., Sun Y., Niu G., Servin A., Nunez J.E., Duarte-Gardea M., and Gardea-Torresdey J.L. CeO_2 and ZnO nanoparticles change the nutritional quality of cucumber (Cucumis sativus). *J Agric Food Chem* 62 (2014) 2752-2759

[15] Mahajan P., Dhoke S.K., Khanna A.S., and Tarafdar J.C. Effect of nano-ZnO on growth of mung bean (Vigna radiata) and chickpea (Cicer arietinum) seedlings using plant agar method. *Appl Biol Res* 13 (2011) 54-61

[16] Singh A., Singh N.B., Afzal S., Singh T., and Hussain I. Zinc oxide nanoparticles: a review of their biological synthesis, antimicrobial activity, uptake, translocation and biotransformation in plants. *J Mat Sci.* 2017; DOI 10.1007/s10853-017-1544-1

[17] Taranath T.C. and Patil B.N. Limonia acidissima L. leaf mediated synthesis of zinc oxide nanoparticles: a potent tool against Mycobacterium tuberculosis. *Int. J. Mycobacteriol.* 5 (2016) 197-204

[18] Jamdagni P., Khatri P., and Rana J.S. Green synthesis of zinc oxide nanoparticles using flower extract of Nyctanthes arbor-tristis and their antifungal activity. *Journal of King Saud University - Science,* 30 (2018) 168-175

[19] Anbukkarasi V.R., Srinivasan, and Elangovan N. Antimicrobial activity of green synthesized zinc oxide nanoparticles from Emblica officinalis. *Int. J. Pharm. Sci. Rev. Res.* 33 (2015) 110-115

[20] Vijayakumar S., Vinoj G., Malaikozhundan B., Shanthi S., and Vaseeharan B. Plectranthus amboinicus leaf extract mediated synthesis of zinc oxide nanoparticles and its control of methicillin resistant Staphylococcus aureus biofilm and blood sucking mosquito larvae. *Spectrochimica Acta – Part A*, 137 (2015) 886-891

[21] Santhoshkumar J., Kumar S.V., and Rajeshkumar S. Synthesis of zinc oxide nanoparticles using plant leaf extract against urinary tract infection pathogen. *Resource-Efficient Technologies, 2017* (2017) 1-7

[22] Xie Y., He Y., Irwin P.L., Jin T., and Shi X. Antibacterial activity and mechanism of action of Zinc oxide nanoparticles against Campylobacter jejuni. *Applied and Environmental Microbiology*, 77 (2011) 2325-2331

[23] Jasim N.O. Antifungal activity of Zinc oxide nanoparticles on Aspergillus fumigatus fungus & Candida albicans yeast. *Journal of Natural Sciences Research,* 5 (2015) 23-27

[24] Siddiqi K.S. and Husen A. Plant response to engineered metal oxide nanoparticles. *Nanoscale Res Lett.* 12 (2017) 92

[25] Pal S., Mondal S., Maity J., and Mukherjee R. Synthesis and characterization of ZnO nanoparticles using Moringa oleifera leaf extract: investigation of photocatalytic and antibacterial activity. *Int. J. Nanosci. Nanotechnol.* 14 (2018) 111-119

[26] Bala N., Saha S., Chakraborty M., Mati M., Das S., Basu R., and Nandy P. Green synthesis of zinc oxide nanoparticles using Hibiscus subdariffa leaf extract: effect of temperature on synthesis, antibacterial activity and antidiabetic. *RSC Adv* 5 (2015) 4993

[27] Bisht G. and Rayamajhi S. ZnO Nanoparticles: A promising anticancer agent. *Nanobiomedicine,* 3 (2016) 1-11

[28] Isha D. and Milind P. Eat til and protect dil. *Int Res J Pharm.* 3 (2012) 2230-8407.

[29] Anand D.T., Pothiraj C., Gopinath R.M., and Kayalvizhi B. Effect of oil-pulling on dental caries causing bacteria. *Afr. J Mic Res* 2 (2008) 063-6

[30] Vishwanath H.S., Anilakumar K.R., Harsha S.N., Khanum F., and Bawa A.S. In vitro antioxidant activity of Sesamum indicum seeds. *Asian Journal of Pharmaceutical and Clinical Research*, 5 (2012) 56-60

[31] Shasmitha R. Health benefits of Sesamum indicum: A short review. *Asian Journal of Pharmaceutical and Clinical Research,* 8 (2015) 1-3

[32] Miraj S. and Kiani S. Bioactivity of Sesamum indicum: A review study. *Der Pharmacia Lettre*, 8 (2016) 328-334

[33] Anilakumar K.R., Pal A., Khanum .F, and Bawa A.S. Nutritional, medicinal and industrial uses of sesame (Sesamum indicum L.) seeds – an overview. *Agriculturae Conspectus Scientificus,* 75 (2010) 159-168

[34] Fuji Y., Uchida A., Fukahori K., Chino M., Ohtsuki T., and Matsufuji H. Chemical characterization and biological activity in young sesame leaves (Sesamum indicum L.) and changes in iridoid and and polyphenol content atdifferent growth stages. *PLoS ONE,* 13 (2018) 1-15

[35] Matthew K.M. Illustrations on the Flora of the Tamilnadu Carnatic. Rapinat Herbarium: Tiruchirapalli, 1982.

[36] Diallo A., Ngom B.D., Park E., and Maaza M. Green synthesis of ZnO nanoparticles by Aspalathus linearis: structural & optical properties. *J. Alloys Compd.* 646 (2015) 425–430

[37] Ravindran C.P., Manokari M., and Shekhawat M.S. Biogenic production of zinc oxide nanoparticles from aqueous extracts of Duranta erecta L. *World Scientific News*, 28 (2016) 30-40

[38] M.O. Ijoyah, J.O. Anyogo, and F.D. Ugese, Yield Response of Maize (Zea mays L.) and Sesame (Sesamum indicum L.) Intercrop as Influenced by Planting Densities and Varieties of Sesame at Makurdi, Nigeria. *World Scientific News* 37 (2016) 25-49

[39] Sutradhar P. and Saha A. Green synthesis of zinc oxide nanoparticles using tomato (Lycopersicon esculentum) extract and its photovoltaic application. *J. Exp. Nanosci.* 11 (2016) 314–327

[40] Manokari M. and Shekhawat M.S. Green synthesis of zinc oxide nanoparticles using whole plant extracts of Cassia tora L. and their characterization. *Journal of Scientific Achievements,* 2 (2017) 10-16

[41] Mirzaei H. and Darroudi M. Zinc oxide nanoparticles: Biological synthesis and biomedical applications. *Ceramics International,* 43 (2017) 907-914

[42] Behzadi S., Ghasemi F., Ghalkhani M., Ashkarran A.A., Akbari S.M., Pakpour S., Hormozi-Nezhad M.R., Jamshidi Z., Mirsadeghi S., Dinarvand R., Atyabi F., and Mahmoudi M. Determination of nanoparticles using UV-Vis spectra. *Nanoscale,* (2014) doi: 10.1039/c4nr00580e

[43] Parthasarathy G., Saroja M., and Venkatachalam M. Bio-synthesized nano-formulation of zinc oxide - Aloe vera and to study their characterization and antibacterial activities against multiple pathogens. *International Journal of Pharmaceutical Sciences and Research,* 8 (2017) 900-907

[44] Devi R.S. and Gayathri R. Green synthesis of zinc oxide nanoparticles by using Hibiscus rosa-sinensis. *Int J Curr Eng Technol* 4 (2014) 2444–2446

[45] Mittal A.K., Chisti Y., and Banerjee U.C. Synthesis of metallic nanoparticles using plant extracts. *Biotechnol Adv* 31 (2013) 346-356