International Journal of Natural and Engineering Sciences
E-ISSN: 2146-0086 17(2): 63-69, 2023
Research Article

Structural electrical and antimicrobial properties of nano copper oxide doped with Tirunelvelica Sanjappa leaves

L.N.Shubha[1]*, Usha Praveena V J[2], S.P.Kanchana[3]

[1]*Department of Electronics, St. Francis College for Women , Begumpet, Hyderabad,India*
[2]*Department of Physics, St.Francis College for Women ,Begumpet, Hyderabad, India*
[3]*Department of Biochemistry , St.Francis College for Women ,Begumpet, Hyderabad, India*

*Corresponding author: shubhastfrancis@gmail.com

(Received: 14 January 2023 / Accepted: 06 April 2023)

Abstract

An upsurge in research for medicinal plants is observed globally. Due to the presence of numerous secondary metabolites, including alkaloids, flavonoids, phenol, terpenoids, saponin, and carbohydrates, Tirunelvelica Sanjappa (TS) leaves have a significant potential to operate as a source of beneficial drugs. The dried leaf powder was subjected to solvent extraction for preliminary secondary metabolites analysis. As a result of the existence of numerous compounds that play a crucial role in maintaining good health, these phyto components appeared to have the potential to work as a source of useful pharmaceuticals and also in the improvement of the patients' physical conditions. Further nano copper oxide was doped with Tirunelvelica sanjappa dried leaves and made in to fine powder for characterization. The powder was characterized by UV-Visible Spectroscopy and FTIR. The D.C. conductivity measurements were performed using two probe methods. At room temperature, D.C. conductivity was found to be 87µS/cm. Enhanced antibacterial activity of the doped CuO/TS leaves was observed due to the synergistic interaction between the CuO and TS leaves

Keywords: Tirunelvelica Sanjappa leaves, UV-Visible Spectroscopy, FTIR and D.C. conductivity , Antibacterial activity

Introduction

Natural derivative of medical plants is considered globally as it is understood that drugs from medicinal plants are secure, free of side effects. According to WHO (2002), 80% of people around the globe are still relying on herbal medicines to treat their diseases[1].In the recent scenario, the need for herbal items is growing exponentially throughout the globe, and also major pharmaceutical companies are presently performing substantial study on plant extracts for their prospective medicinal worth. This is due to belief of researchers that ligand/leads discovery would be more feasible in medical plants as well as which are yet to be completely analysed [2]. An annual upright herb in the family Fabaceae, Tirunelvelica Sanjappa has branches that are woody, angular, light brown pubescent when young, terete, striate, and also glabrous when they reach maturity [3]. Petioles 1 to 3 centimetres long, thin, and canaliculated above; leaves 5-6 cm long, pinnately trifoliolate, alternate. Bracts are 1-1.5 mm long, lanceolate, severe, pubescent without, caducous, and have pubescence without glands. Flowers are pink and 5 mm long. Wattles are 1-1.5 mm long, 5-lobed, and 2mm long [4]. Flowers bloom during November to December months and fruiting is during December to March. Tirunelvelica sanjappa are found near Tirunelveli Hills, Tamil Nadu [5]. Both the electroanalytical method and the in vitro antioxidant capacities of Indigofera tirunelvelica Sanjappa have been investigated.There are no records concerning its chemical components and also pharmacology, safety and also utilizes previously. In the present study nano copper oxide is doped with Tirunelvelica sanjappa (TS) to understand how metal oxide can alter the electrical properties. Among those metal Oxide nanoparticles, Copper Oxide (CuO) nanoparticles are appealing because of their excellent physical and chemical properties [6-7]. Copper Oxide (CuO) is frequently used as anode materials for Litium ion batteries owing to its high capacity, safety and low-cost [8]. They are also used in sensor applications [9-12]. Therefore, the aim of the present work is to prepare nano CuO / TS leaves composite and to study their structural and electrical properties. The present study helps in understanding how the prepared sample can be used in biosensor applications.

Materials and Methods

Materials

Cupric Nitrate, NaOH, Acetone and Dimethyl sulfoxide was purchased from S.D. Fine Chemicals. All the solutions were made using double distilled water. The plant was collected from Tirunelveli, Tamil Nadu dried and made in to fine powder.

Sample preparation

Copper oxide nanoparticle

CuO nano-particles were synthesized by adopting wet chemical method. For the synthesis of CuO nano particles the precursor used was Cupric Nitrate with water as medium. Copper Oxide nano particles were prepared by using 0.2 M of Cupric Nitrate and dissolving it in 100 ml of deionized water. This solution was stirred continuously for 1Hour. To this solution, 0.2 M NaOH was added drop wise till the pH of the solution was 10. Black precipitate was formed in the beaker. This precipitate was centrifuged and washed with methanol and distilled water. The collected black colour powder was calcined at 350ºC.

CuO / TS leaves composite

The prepared Copper Oxide powder and TS leaves powder was dissolved in Dimethyl sulfoxide (DMSO) and sonicated. Further the solution was stirred for 11 hrs at room temperature. Later the solution was filtered and centrifuged. Further the powder was thoroughly washed with water and acetone. The collected powder was kept in oven at 60^0C for 24 hours for drying.

Characterization

U.V visible absorbance spectra were recorded on Double beam UV-Spectrometer (Systronics – 2201).The wavelength range was observed from 200 - 1100nm. The FTIR spectra of the PANI were taken on a Thermo Nicolet Nexus 670 Spectrometer preparing pellets of samples with KBr. Conductivity measurements were made on compressed pellets of the powder using conventional two probe technique. By using the Agar Well Diffusion method, the samples' antimicrobial activity was evaluated.

Results and Discussion

UV–visible spectra

The UV -Visible spectra of CuO , TS leaves and CuO / TS leaves composite is shown in figure 1. In case of CuO a wide absorption peak is observed in the wavelength range 305nm to 355 nm [13-14]. In the case of TS leaves, the peak centered at 220nm. In case of CuO / TS Leaves Composite the peak centered at 220nm shows blue shift to 210nm. In addition a small peak around 300 nm is observed in the composite. This indicates the presence of CuO in the composite. Blue shift also indicates the interaction between CuO and TS Leaves.

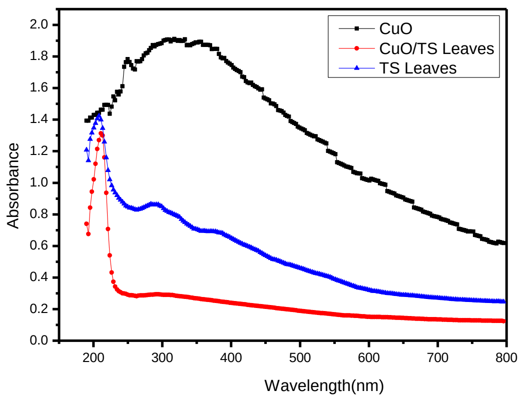

Figure 1. *UV Visible spectra for CuO . TS leaves and CuO / TS leaves composites*

FTIR studies

FTIR spectra of CuO, TS leaves and CuO / TS leaves composite are shown in figure 2. It is obvious from the figure that CuO has characteristics peaks at Wave numbers 3361, 1636, 725, 610 and 497cm^{-1}[15,-16]. The peak 3361 cm^{-1} arises from OH stretching vibrations. The peak 1636 cm^{-1} is due to OH- bending and 725 and 610 cm^{-1} wave numbers are due to Cu-O stretching. The main characteristics peaks of TS leaves are 2955,2359,1711,1642,1463,1081and771cm^{-1}.FTIR analysis results proved the presence of alkanes, hydroxyl ,ketones, Amino acid, aromatics ,amines and phenols which shows major peak at 2955,2359,1711,1642,1463,1081and 771 cm^{-1} respectively [17]. Peak 2955, 2359 1463,1081 of TS leaves appear in the sample of CuO / TS leaves composites. The peak of CuO 3361 cm^{-1} arising due to OH stretching vibrations is observed in CuO / TS leaves composite. These peaks indicate doping of CuO nanoparticles in the composite.

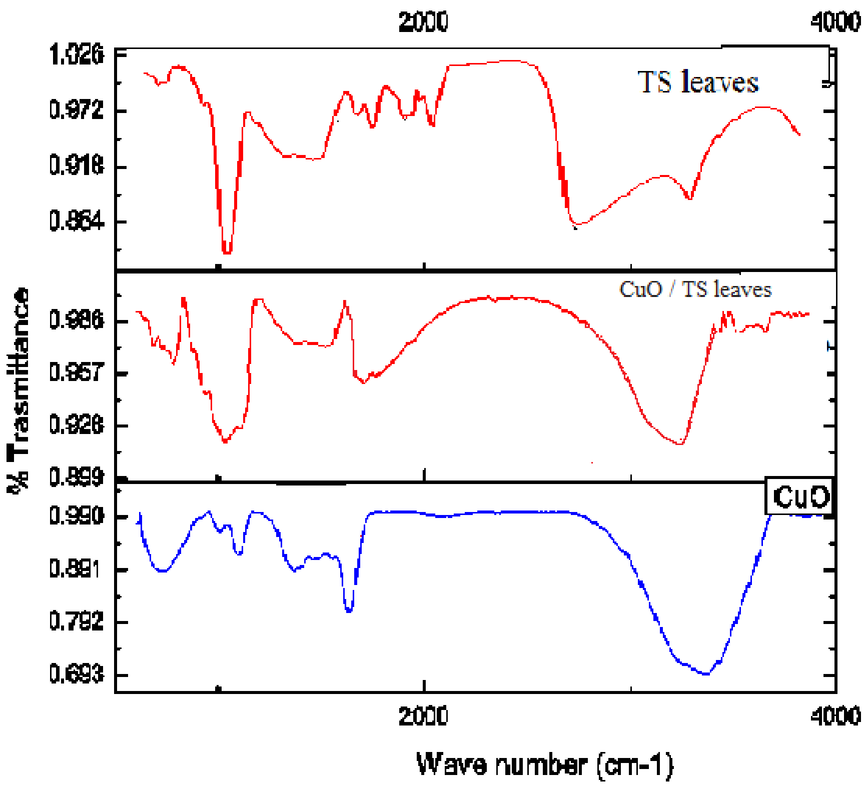

Figure 2. *FTIR pattern of CuO, TS leaves and CuO / TS leaves composite*

Electrical investigation

Electrical investigation is one of the most important characteristics of a conducting polymer, especially to explore their use in electrical devices. An attempt was made to measure D.C Conductivity for different temperature. For electrical properties the powder was made in to pellets by uniaxial pressing.

D.C. Conductivity

A pressed pellet is subjected to a two-probe conductivity experiment to determine its conductivity at room temperature. DC Conductivity is measured by the formula

$$\sigma_{dc} = (L / R^* A)$$

Where 'R' is the resistance, 'L' is the thickness of the pellet and 'A' is the area of cross section of the pellet.

It is observed that the resistivity increased in case of CuO / TS leaves composite when compared to TS leaves [18-20].

Table 1. Conductivity measurement of TS leaves, CuO / TS leaves composite & CuO

S.no	Sample	Conductivity (S/cm)
1	TS leaves	8.07E-12
2	CuO / TS leaves composite	8.21E-05
3	CuO	1.21E-05

D.C. Conductivity was also measured for varying temperature (25^0 C to 100^0C). It has been found that as temperature rises, resistance falls and D.C conductivity rises. The composite therefore displays semiconductor behaviour. Even at temperatures as high as 100^0 C, the sample demonstrated semiconductor characteristics. Further temperature increases are not feasible since beyond 100^0 C, the plant will be completely annihilated .Hence this material is well suited for biosensor applications.The graph between temperature and D.C. Conductivity is shown in Figure. 3

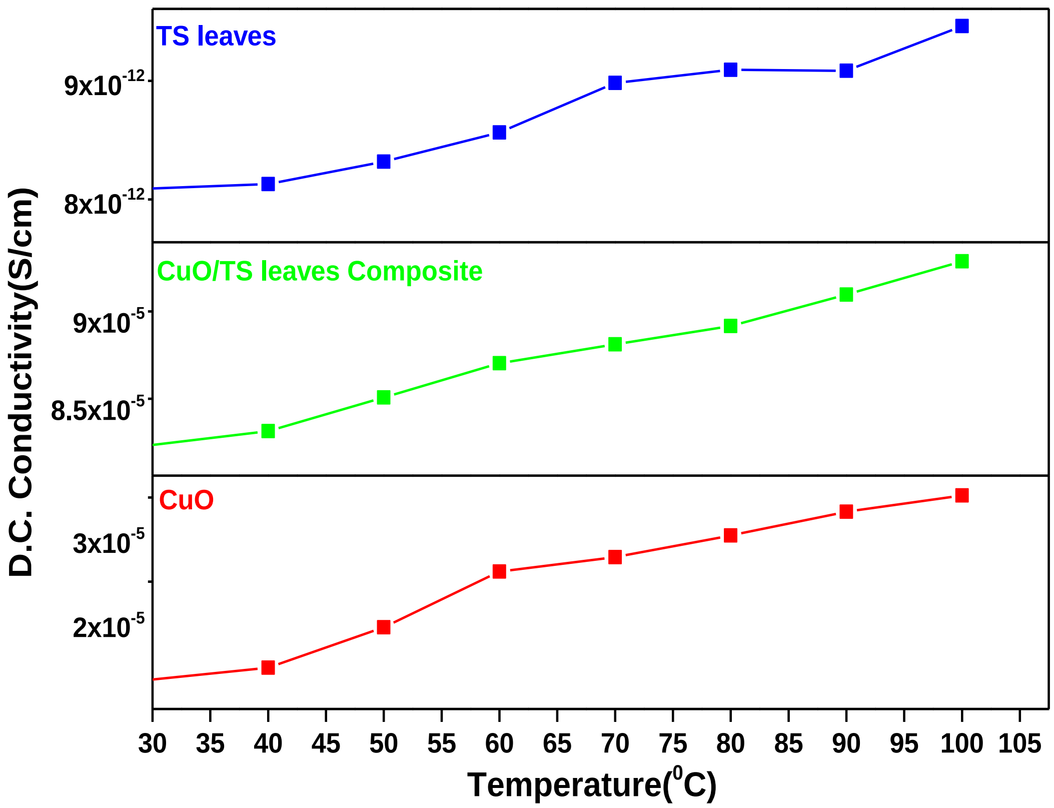

Figure 3. *D.C conductivity of CuO, TS leaves and CuO / TS leaves composite as a function of Temperature*

Antibacterial Activity

By using the Agar Well Diffusion method, the samples' antimicrobial activity was evaluated against Gram-positive Bacillus species and Gram-negative Escherichia coli (E.coli) . Agar diffusion is a technique for evaluating an antimicrobial agent's effectiveness against bacteria.

A concentration of CuO , TS leaves and CuO / TS leaves was impregnated into wells that had been drilled into the agar. From the well, the substance diffuses into the agar. The compound will be most concentrated close to the well, and as distance from the well increases, it will diminish. No colonies will develop if the compound's concentration in the agar is greater than or equal to the concentration at which it is effective against bacteria. Table 2 shows the inhibition zones on Bacillus species and E. coli SPS at various concentrations of CuO, TS leaves, and CuO/TS leaves.

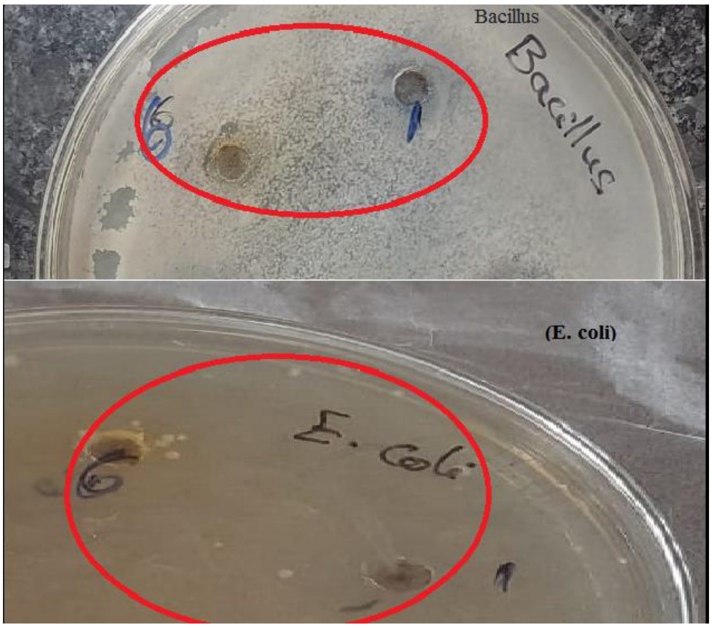

Figure 4. *Photographic image of zones of inhibition of TS leaves and CuO / TS leaves on Bacillus species and Escherichia coli (E. coli)*

Table 2. Inhibition zones at various concentrations of CuO, TS leaves and CuO / TS leaves ON Bacillus species and E. COLI SPS

S.no	Organism	Zone of Inhibition		
		TS leaves	CuO / TS leaves composite	CuO
1	Bacillus species	No Activity	15mm	17mm
2	Escherichia coli (E. coli)	No Activity	8mm	12mm

From figure 4 it was observed that Gram-positive Bacillus species is more susceptible to the antibacterial effects of CuO/TS leaf combination than Gram-negative Escherichia coli (E. coli). CuO / TS leaves composite exhibited because of the presence of CuO nano particles, despite the fact that alone leaves did not show any activity against bacteria. A synergistic interaction between the CuO and TS leaves and the breakdown of proteins in bacterial cells brought on by the attachment of Cu2+ ions to the bacterial cell surface are the contributing factors to the improved antibacterial activity of the doped CuO/TS leaves.

Conclusions

Using a wet chemical technique, CuO nanoparticles were synthesized. By using a solution mixing approach, a composite made of CuO and TS leaves was synthesized . The incorporation of nano CuO in the composite was confirmed by the UV-visible spectrum and FTIR. Due to the doping of CuO, CuO/TS leaves composite samples have been linked to a rise in DC conductivity. Gram-negative Escherichia coli is less resistant to the antibacterial actions of the CuO/TS leaf combination than Gram-positive Bacillus species. CuO/TS leaves composite may be useful for biosensor applications with further characterization.

References

[1] World Health Organization, WHO traditional medicine strategy 2002-2005.

[2] Chien, T. J. (2018). The concern and prospective between precision medicine and traditional Chinese medicine. *Longhua Chinese Medicine*, *1*(12).

[3] Ibrahim, J., Ajaegbu, V. C., & Egharevba, H. O. (2010). Pharmacognostic and phytochemical analysis of Commelina benghalensis L. Ethnobotanical Leaflets, 2010(5), 7.

[4] Kanchana, S. P., & John, A. A. (2020). Pharmacognostic and Phytochemical studies of Indigofera tirunelvelica Sanjappa. Research Journal of Pharmacy and Technology, 13(2), 923-927.

[5] Subburayalu S; Asha KRT; Deepa Somanath; Palavesam A.(2020) Hepatoprotective Potential of Indigofera Tirunelvelica Sanjappa: In Vitro and in Vivo Studies on CCl4 Induced Wistar Albino Rats. ijrps 0, 11, 6404-6410.

[6] Chauhan, V., & Pandey, A. (2015). A revision of trifoliolate Indigofera (Tribe Indigofereae: Fabaceae) in India. *Phytotaxa*, *220*(1), 1-29.

[7] Sanjappa, M. (1982). Indigofera tirunelvelica--a new species from Tamil Nadu, S. India. Journal of the Bombay Natural History Society.

[8] Liu, A., Bac, L. H., Kim, J. S., Kim, B. K., & Kim, J. C. (2013). Synthesis and characterization of conducting polyaniline-copper composites. Journal of nanoscience and nanotechnology, 13(11), 7728-7733.

[9] Erdoğan, İ. Y., & Güllü, Ö. (2010). Optical and structural properties of CuO nanofilm: its diode application. Journal of Alloys and Compounds, 492(1-2), 378-383.

[10] Cuong, H. N., Pansambal, S., Ghotekar, S., Oza, R., Hai, N. T. T., Viet, N. M., & Nguyen, V. H. (2022). New frontiers in the plant extract mediated biosynthesis of copper oxide (CuO) nanoparticles and their potential applications: A review. *Environmental Research*, *203*, 111858.

[11] Tanzifi, M. (2014). Modification of polyaniline/polystyrene and polyaniline/metal oxide structure by surfactant. International Journal of Engineering, 27(2), 227-238.

[12] Li, Y., Liang, J., Tao, Z., & Chen, J. (2008). CuO particles and plates: synthesis and gas-sensor application. Materials Research Bulletin, 43(8-9), 2380-2385.

[13] Jindal, K., Tomar, M., & Gupta, V. (2012). CuO thin film based uric acid biosensor with enhanced response characteristics. Biosensors and Bioelectronics, 38(1), 11-18.

[14] Basu, T. (2012). Tuning of chemical switching properties of nanostructured conducting polyaniline using structure directing agents. Science Journal of Biotechnology, 2012.

[15] Gandhi, S., Subramani, R., Ramakrishnan, T., Sivabalan, A., Dhanalakshmi, V., Nair, M. R., & Anbarasan, R. (2010). Ultrasound assisted one pot synthesis of nano-sized CuO and its nanocomposite with poly (vinyl alcohol). Journal of materials science, 45(6), 1688-1694.

[16] Shubha, L. N., Kalpana, M., & Madhusudana Rao, P. (2015, July). Study of Chemically Synthesized Polyaniline/CopperOxide Nanocomposites. In Proceedings of the National Seminar on Frontiers in Chemical Research and Analysis, Hyderabad, India (pp. 24-25).

[17] Bobby, M. N., Wesely, E. G., & Johnson, M. (2012). FT-IR studies on the leaves of Albizia lebbeck benth. Int J Pharm Pharm Sci, 4(3), 293-296.

[18] Vitoratos, E., Sakkopoulos, S., Dalas, E., Malkaj, P., & Anestis, C. (2007). DC conductivity and thermal aging of conducting zeolite/polyaniline and zeolite/polypyrrole blends. Current Applied Physics, 7(5), 578-581.

[19] Alturki, A. M. (2022). Facile synthesis route for chitosan nanoparticles doped with various concentrations of the biosynthesized copper oxide nanoparticles: Electrical conductivity and antibacterial properties. Journal of Molecular Structure, 1263, 133108.

[20] Wu, J., Wu, Y., Yuan, Y., Xia, C., Saravanan, M., Shanmugam, S., ... & Pugazhendhi, A. (2022). Eco-friendly, green synthesized copper oxide nanoparticle (CuNPs) from an important medicinal plant Turnera subulata Sm. and its biological evaluation. Food and Chemical Toxicology, 168, 113366.