Green Synthesis and Characterisation of CuO Nanoparticles Prepared Using Adenanthera Pavonina Leaves Extract

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A B S T R A C T: Development of green technology is generating interest in researcher towards eco-friendly and low-cost method for biosynthesis of nanoparticles. In this study, green synthesis of copper oxide nanoparticles using copper chloride dihydrate precursor and Adenanthera Pavonina Leaves extract as reducing and capping agent during the synthesis. GS- CuO nanoparticles were characterized by UV-vis absorption Spectroscopy, Fourier Transform Infrared Spectroscopy (FT-IR), X-ray Diffraction (XRD) and Transmission Electron Microscope (TEM). The existence of the CuO nanoparticles was revealed by UV-vis spectroscopy. The FTIR spectra of leaf extract and synthesised CuO nanoparticles identifies the functional groups of the active components. The formation of CuO nanoparticles has been confirmed by X-ray diffraction and average crystallite size for assign peaks were 39.24nm. The morphology of biosynthesized nanoparticles was found to be 11.16nm.

Keywords: Green synthesis, Adenanthera Pavonina Extract, Copper Oxide Nanoparticles, Characterization

1. Introduction

Nanotechnology generally involves the application of extremely small particles that are used across all fields of science including chemistry, biology, medicine and material science [1-4]. According to Sathiyavimal et.al [5], Nanotechnology deals with the synthesis of metal and metal oxide nanoparticles of different sizes, shapes, disparity and chemical composition. Nanoparticles which by definition are the clusters of atoms in the size range of 1-100 nm are the major building blocks of nanotechnology [6-7]. Metal and metal oxide nanoparticle is a highly valuable material with various applications in optical, electrical, and mechanical devices, catalyst, gas sensor, sunscreens and cosmetics [8]. Several chemical and physical method have been used for their synthesis such as lol-gel, precipitation, sonochemical, electro thermal, synthesis, vapour deposition, and electro chemical methods [9-10]. Most of these methods are complicated and difficult to isolate nanoparticles and long time required etc [11]. Traditional methods are used from past many years but researches have proved that the green methods are more effective for the generation of NPs with advantage of less chances of failure, low cost and ease of characterization.[12] In the green synthesis method in which nanoparticles with biocompatibility are produced these agents are naturally present in the employed biological organism. Synthesis can be done in one step using biological organism such as Bacteria, Actinobacteria, yeast, moulds, algae, and plants (or) their products. The plants are considered to be more suitable compared to microbes for green synthesis of nanoparticles as they are non-pathogenic and various pathways are thoroughly researched. The plants (or) plants extract, which act as reducing and capping agents for nanoparticle synthesis, are more advantageous over other biological process [13]. The different parts of plant materials such as extracts. Fruit, fruit peels, bark, root, leaves, and tubers [14]. The materials present in the plant extract such as sugar, flavonoid, protein, enzyme, polymer, and genie acid acting as a reducing agent take charge in bio induction of metal ions into nanoparticles. [15-19].

Nowadays, the CuO nanoparticles is an important metal oxide which has attracted recent researchers because of its low cost, abundant availability as well as its particular properties [20]. Green synthesis of copper oxide nanoparticles is of great interest because many advantages: copper is highly conductive also cheaper than Silver and Gold [21]. The important applications of CuO nanoparticles such as sensor, catalytic, optical, electrical, high temperature superconductor, solar energy conversion tools and so on [22-25]. Nanoparticle application for removal of pollutant has come up an interesting area of research. The unique properties of nano sorbents are providing unprecedented opportunities for the removal of dyes in highly efficient and cost-effective approaches.

The aim of present work is to synthesis CuO nanoparticles using environmentally friendly green method from copper chloride dihydrate salt and Adenanthera Pavonina leaves extract and characterise of their structure.

2. MATERIALS AND METHODS

2.1 Materials

Adenanthera Pavonina Leaves collected from local area in Chennai, Tamilnadu. Analytical grade material was used without any further purification in addition to deionised water, Copper chloride dihydrate ($CuCl_2.2H_2O$), Sodium hydroxide (NaOH), Ethanol (C_2H_5OH).

2.2 Methods

2.2.1 Preparation of Adenanthera Pavonina Leaves Extract

The Adenanthera pavonia leaves were collected from Ashok Nagar, Chennai. The fresh leaves were washed several times with tap water followed by distilled water to remove the dust particles. The clean and fresh sources are dried in a shaded place at room temperature for 10 to 15 days and then the leaves were pulverized using commercial blender. The fine powdered was stored at room temperature for further use. In a 250 ml of conical flask 10 gm of leaf powder were taken and to this 100 ml of double distilled water is added and it is heated at 80^oC for 30 minutes. Then the solution was filtered using Whatman filter paper and kept aside for further process. The obtained extract in pale brown colour and adjust the pH at 11 by adding 0.1M of sodium hydroxide solution.

2.2.2 Preparation of Copper Oxide Nanoparticles

In a 250 ml conical flask, 50 ml of Adenanthera pavonia leaves extract was taken and to this 100 ml of 0.1 M $CuCl_2.2H_2O$ solution is added slowly at room temperature under static conditions. The colour change of the reaction was observed and the time taken for the changes was noted. The solution colour changes immediately from pale brownish to yellowish grey colour indicating the formation of copper oxide nanoparticles (CuONP). Further the solution is centrifuged and precipitated is extracted and dried in electrical oven for 24 hours at 100^oC. the dried sample kept in muffle furnace for 4 hours at 500^oC. the green synthesised CuONPs is formed at uniform particle size and stored for further characterisation and uses.

2.3 Characterization of Copper Oxide Nanoparticles

2.3.1 UV-Visible spectrophotometric analysis

Synthesized CuO nanoparticles were subjected to UV-Vis spectroscopy analysis, which confirms the formation of nanoparticles in the initial stage. The CuO nanoparticles synthesized were subjected to scan UV-Vis spectrophotometer in the range 190 nm - 800 nm using Elico SL210 UV VIS Spectrophotometer.

2.3.2 FT-IR Spectroscopic analysis

The plant extract and green synthesized CuO nanoparticles were characterized by FT-IR spectrometer. The spectroscopic technique is based on the analysis of peaks at certain wave numbers. FT-IR data indicates the presence of functional groups in the plant extract and synthesized nanoparticles. The FT-IR analysis carried out in the frequency range of 4000 - 400 cm^{-1} using Perkin Elmer instrument

2.3.3 X-ray diffraction analysis (XRD)

X-ray diffractometer was used to study the average particle size and crystalline nature of the synthesized adsorbents. The diffraction pattern was obtained by using CuKα radiation with wavelength of λ=1.541A^o. The scanning was done in 2θ value range of 4^o to 80^o at 0.02 min^{-1} and one second time constant.

2.3.4 Transmission Electron Microscope (TEM)

TEM is regarded as the best among other electron microscopy techniques for the determination of particle size and morphological identities of CuONPs and other metal nanoparticle.

3. Results and Discussion

3.1 UV- vis Absorption Spectroscopy for copper oxide Nanoparticles.

The Green approach for the formation of copper oxide nanoparticles using Adenanthera pavonina leaves extract was reported. Formation of copper oxide nanoparticle were confirmed by UV-vis spectrophotometry. Fig.1 shows the UV-Vis absorption spectrum of copper oxide nanoparticle. The adsorption spectrum was recorded for the sample in the range of 200 – 800 nm. The spectrum showed the absorbance peak at 280 nm corresponding to the characteristic band of copper oxide nanoparticle [3].

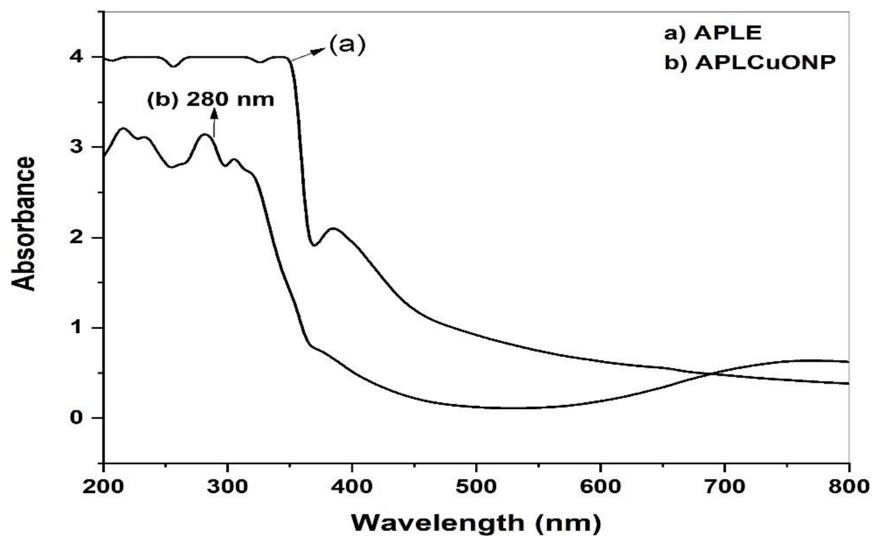

Fig 3.1. UV-vis absorption spectrum of a) Adenanthera Pavonina leaves extract (b) synthesized APCuO nanoparticles

3.2 Fourier Transform Infra-Red Spectroscopy (FTIR)

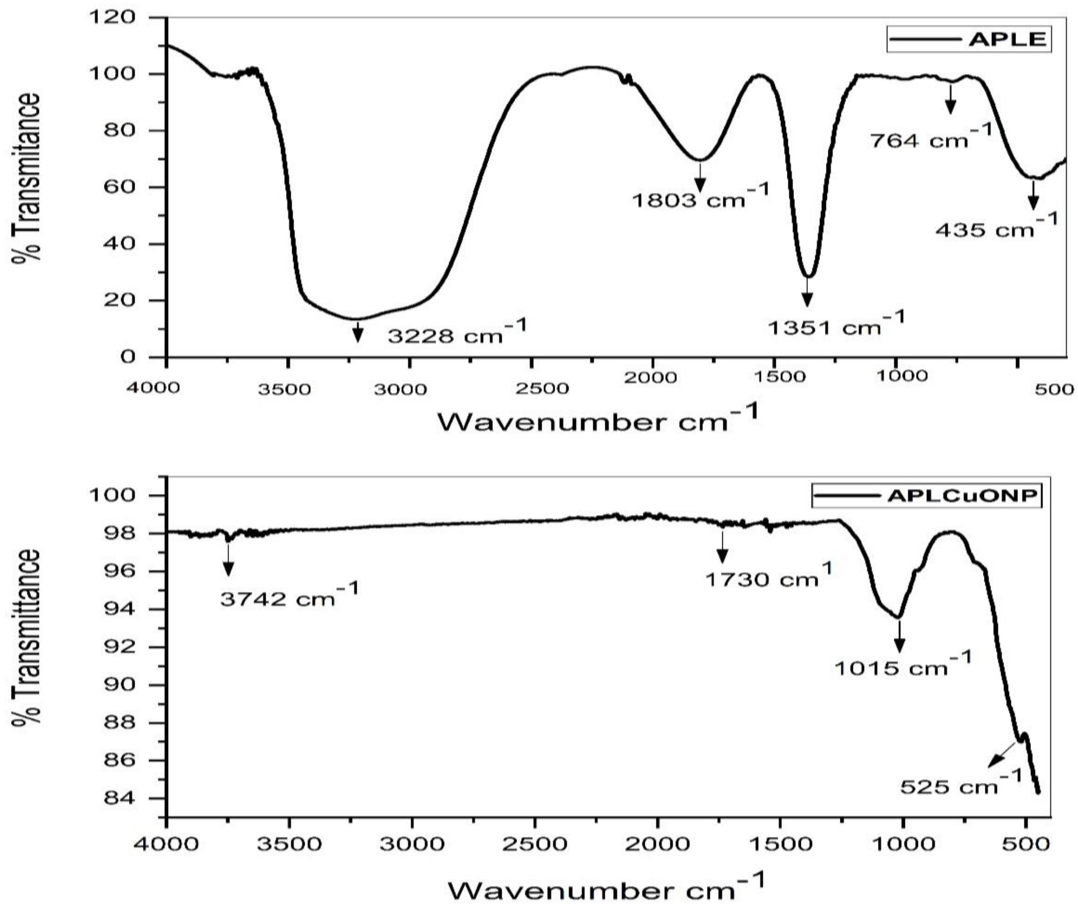

Fig 3.2. FT-IR Spectrum of APL extract and APLCuONPs

FTIR spectroscopy analysis also revealed the possible biomolecules and functional group responsible for the capping or stabilizing of the green synthesized CuONPs. FTIR spectrum of leaves extract control, the involvement of different functional group of Adenanthera Pavonina leaves extract reducing and stabilizing process of nanoparticle synthesis was evaluated. Absorbance band at 3228 cm^{-1}, 1803 cm^{-1}, 1351 cm^{-1}, and 764 cm^{-1} were observed in spectrum of adenanthera pavonine leaves extract. A broad band at 3228 was due to the OH stretching vibration alcoholic or phenolic compounds. The 1803 cm^{-1} such as C=O bond stretching, the peak 1351 cm^{-1} and 764 cm^{-1} could be assigned due to the C-H bends [5].

The FTIR spectrum of green synthesis CuONP, the most significant adsorption peaks were those observed of 525 cm^{-1} that corresponds to the stretching vibration of Cu-O bond in monoclinic CuO [6]. The strong peaks at 1015 cm^{-1} were due to C-O stretching vibration of carboxylic group and flavanones. The peaks at 1730 cm^{-1} were due to aromatic C≡C bending vibration. The 3742 cm^{-1} due to OH stretching in water.

3.3 X-ray diffraction analysis

The x-ray diffraction (XRD) study was undertaken to Determine and confirm the crystalline structure of synthesized CuONPs. Fig (3) Shows the appearance of diffraction pattern at 2θ= 33.3, 35.4, 38.8, 48.7, 58.3, 61.8, 66.28 and 68.0 which are assigned to the planes (110), (022), (111), (200), (202), (020), (202), (022) respectively of monoclinic phase CuONPs. No characteristic peak due to any impurity was observed in the diffraction grams Suggesting the formation of pure crystalline CuO.

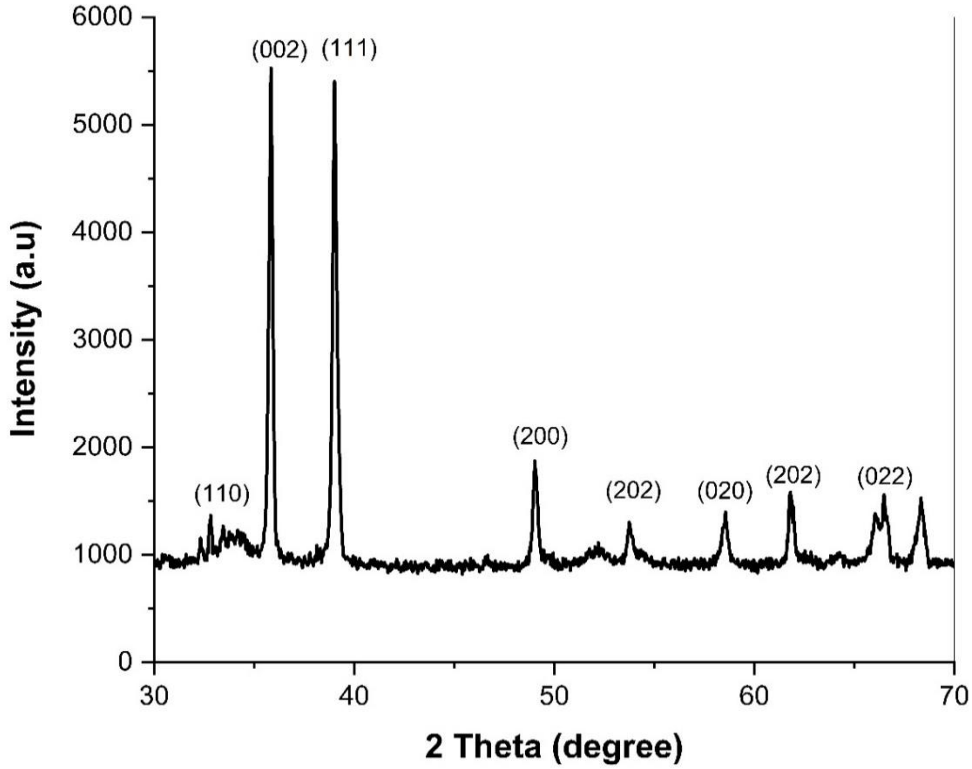

Fig 3.3. XRD pattern of prepared copper oxide nanoparticles

The average size of the CuO was calculated by using the Debye-Scherer Equation (3) [4]. A sharp peak at 2θ=35.4 and 38.8 with the diffraction of the (022) and (111) plane indicates that confirmation of CuONPs. The average crystallite size in the samples of CuONPs is below 39.24nm.

$$D = 0.9\lambda / \beta \cos \theta \qquad \text{Eq. 1}$$

Where λ is the wavelength of the x-ray radiation (0.154nm), θ is the Diffraction angle and β is the full width at half maximum.

3.4. Transmission Electron Microscope (TEM)

Transmission electron microscope of copper oxide nanoparticle are shown Fig 3.4. the estimate average particle size of copper oxide nanoparticle is found to be 11.16 nanometres as calculated by using image-J programme.

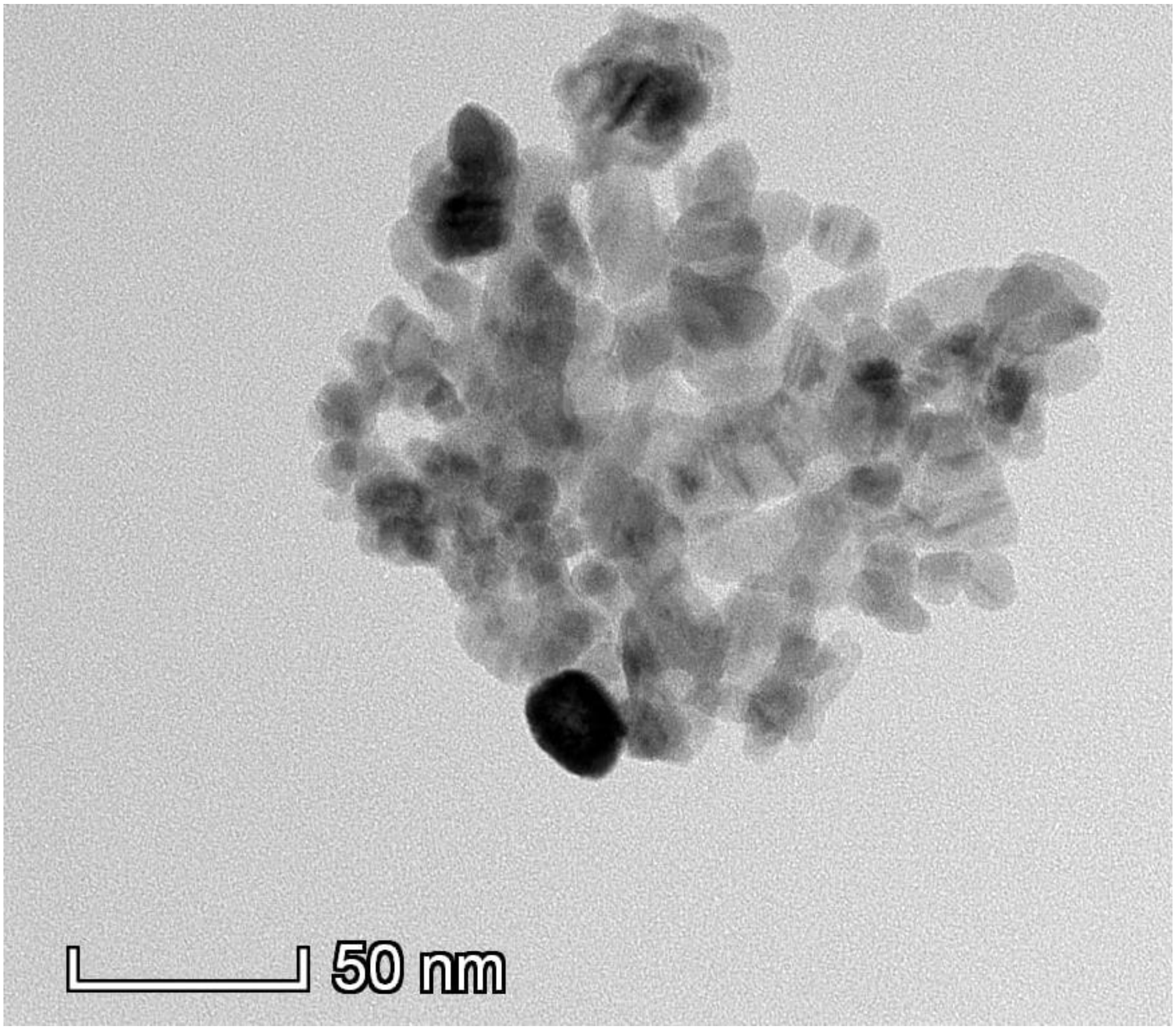

Fig 3.4.1. TEM images of prepared copper oxide nanoparticle

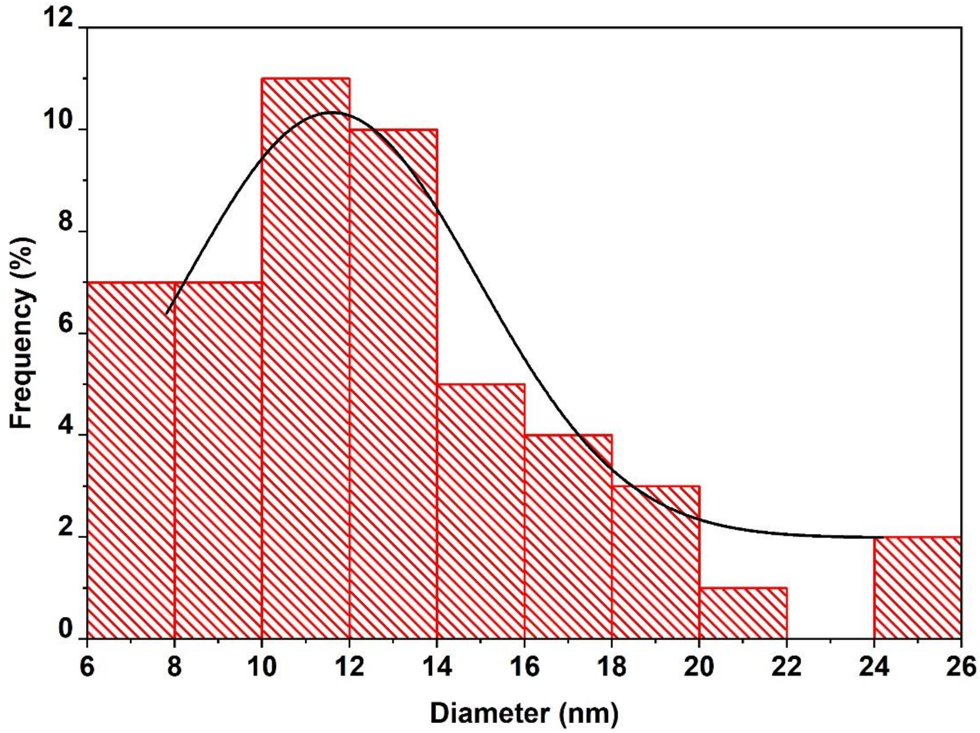

Fig 3.4.2. Histogram of Copper Oxide Nanoparticle

4. Conclusion

The green chemistry approach used in the present work for the synthesis of copper oxide nanoparticles were prepared well by using Adenanthera Pavonina Leaves extract method. The copper oxide nanoparticles were characterized by UV-vis, FT-IR, XRD, and TEM. CuO nanoparticles prepared from above mentioned route are expected to have more extensive applications such as reducing, stabilizing and efficient antimycobacterial agent, chemical sensor and semiconductor etc. This process is an economical method for the preparation of nanocrystalline CuO with respect to energy, time, simplicity and can be used for large scale synthesis of copper oxide nanoparticles. The future work is going to be based on dye removal using green synthesized nanoparticles.

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