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Facile Green Synthesis and Analysis of CuO Nanoparticles Using *Musa Acuminata* Leaves Extract

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Abstract

In recent years synthesis of CuO has lot of attention due to catalytic, electric, optical, photonic, textile, nanofluid, and antibacterial activity depending on the size, shape, and neighbouring medium. The synthesis of metal oxide nanoparticles using plant extract is environmental friendly and cost effective method. Plant extracts will act both as reducing and capping agents in the synthesis of nanoparticle. In the current study, we have carried out green synthesis of copper oxide (CuO) nanoparticles (NPs) using *Musa acuminata* leaves extract as capping agent and Copper nitrate as metal precursor. The synthesized CuO nanoparticles were characterized by XRD, SEM, EDAX, FTIR and UV-VIS spectra to study the crystalline size, morphology, elemental composition and surface properties of nanoparticles.

Key words: CuO, *Musa acuminata,* Copper nitrate

1. Introduction

Nanotechnology is science, engineering and technology conducted at the nanoscale, which is about 1 to 100 nanometers. Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering (1).The prefix “nano” has found in last decade an ever-increasing application to different fields of the knowledge. Nanoscience, nanotechnology, nanomaterials or nanochemistry are only a few of the new nano-containing terms that occur frequently in scientific reports, in popular books as well as in newspapers and that have become familiar to a wide public, even of non-experts (2). physicochemical properties such as large surface area, mechanically strong, optically active and chemically reactive make NPs unique and suitable applicants for various applications. The literature revealed that NPs perform best when the size is critical value i.e. 10–20 nm (3). At such low scale the magnetic properties of NPs dominated effectively, which make these particle priceless and can be used in different applications (4). The uneven electronic distribution in NPs leads to magnetic property. These properties are also dependent on the synthetic protocol and various synthetic methods such as solvothermal (5) co-precipitation, micro-emulsion, thermal decomposition, and flame spray synthesis can be used for their preparation (6).The large total surface area also increases the stability suspension (7). Recently it has been demonstrated that the nanofluids consisting of CuO or Al_2O_3 NPs in water or ethylene exhibit advance thermal conductivity (8).

Manufacture NPs display physicochemical characteristics that induce unique electrical, mechanical, optical and imaging properties that are extremely looked-for in certain applications within the medical, commercial, and ecological sectors (9). Metal oxide nanomaterials are versatile materials. As semiconductors, they are utilized as active materials for various kinds of chemical and physical sensors for detecting gases, chemical species, light, temperature, and bio-species, while reduced or doped metal oxides are applied to electrical and thermal conductors. On the other hand, as metal oxides show either n- or p-type behaviour, depending on their own defect structure or doping elements, they are used as active layers of field effect transistors, and carrier transport layers in various types of optoelectronic devices. Furthermore, some metal oxides, such as iron oxides have magnetic characteristics, and some metal oxides are utilized for battery electrodes. Depending on the synthesis routes, metal oxide nanomaterials have various kinds of morphologies (i.e., nanoparticles, nanowires, and nanoparticle-nanowire hybrid structures), are hence utilized for diverse applications. Moreover, electrical and chemical properties are subjected to the different synthesis methods. Copper nanoparticles research is gaining increasing interest due to their unique properties, CuO nanoparticles act as semiconductors solar energy transformation, and high-tech superconductors.

Green chemistry is a set of practices or principles that encourage the design of products and processes that reduce or eliminate the use and generation of hazardous substances. Many plant parts such as flower extract of *Lantana camara*, *basilicum* plant extract *Centella asiatica (L.)* leaves aqueous extract of *Abutilon indicum*, *Desmodium gangeticum* root extracts, *Drypetes sepiaria* Leaf extract (DSLE) can be used to synthesis Copper oxide nano particle was already reported. In the present work , We choose leaves part of plant namely *Musa acuminata* has been used for synthesis of Copper nanoparticle.

2. Material and Methods

2.1 Materials

All the reagents used in this experiment were obtained from Sigma Aldrich chemicals India. Double distilled water was utilized for all processes. Filtration was done using Whatman no.1 filter papers. Glasswares used for the reactions were washed well, rinsed with double distilled water and dried in hot air oven.

2.2. Methods

2.2.1. Collection of *Musa acuminata* Leaves

Musa acuminata was collected from Raja Gopal Nagar, Thoothukudi District.

2.2.2. Preparation of the *Musa acuminata* Leaves Extract

The collected *Musa acuminata* was incised into small pieces, washed well with double distilled water to dirt and other foreign materials. About 10 grams of dried *Musa acuminata* were weighed and transferred into 250mL beaker containing 100mL of water and boiled well for 30 minutes. The extract obtained was filtered through Whatman No-40 filter paper and the filtrate was collected in a 250mL beaker and stored in refrigerator for further use. All the experiment was carried out using this extract.

2.2.3. Green synthesis of Copper Oxide Nanoparticles

In this method Copper oxide was used as a precursor and *Musa acuminata* leaves extract as a reducing and stabilizing agent for the synthesis of Copper Oxide nanoparticle. For the green synthesis of Copper Oxide nanoparticles, 50mL of previously prepared *Musa acuminata* **leaves** extract was taken in a 100mL beaker. To this 2g of Copper Nitrate solution was added and the solution in the beaker was stirred in a heating magnetic stirrer at 80^oC until the black colour paste was obtained. Then the paste was collected in a ceramic crucible and calcinated in Muffle Furnace at 350^oC. A black coloured powder of Copper Oxide nanoparticles was obtained and this was carefully collected and preserved in the air-tight sample tubes for further studies.

2.3. Characterization

UV-Vis spectral analysis was performed on a JASCO,V-600 spectrophotometer at Anja College, Sivakasi, Thoothukudi. SEM and EDX was recorded at Karunya University, Coimbatore. XRD was recorded in Brucker-D8 by using monochromatic Cu Kα radiation with a wavelength of 1.54Å at Karunya University, Coimbatore.

3. Result and Discussion

3.1. UV Visible Spectroscopy

The Copper Oxide nanoparticles were synthesized from *Musa acuminata* leaves extract. The formation of Copper oxide nanoparticles from Copper nitrate was monitered by UV-Visible spectroscopy. UV-Vis spectra of synthesized CuO NPs from *Musa acuminata* leaves extract are shown in fig.3.1.

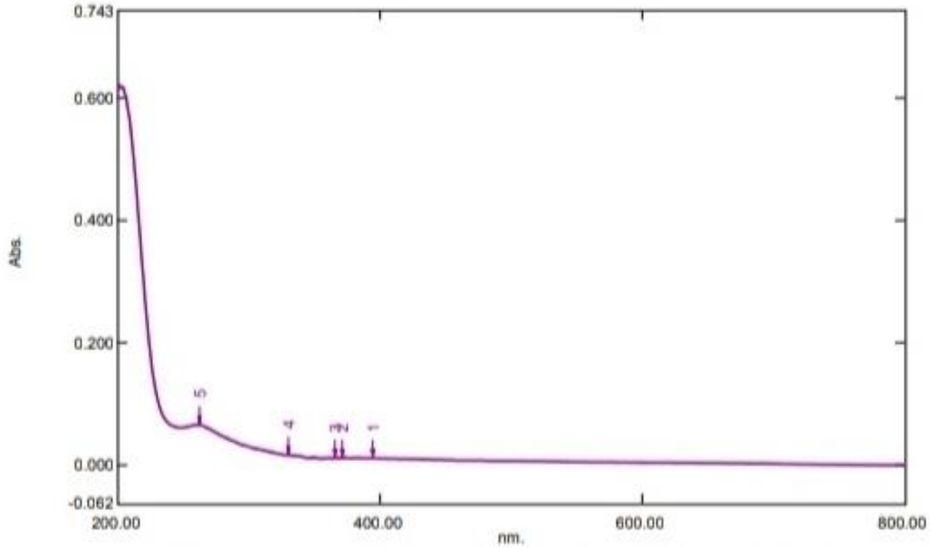

Fig.3.1. UV – Vis spectra of CuO NPs synthesized from the extract of *Musa acuminata* leaves

The peak observed at 292nm, 394 nm indicated the presence of aromatic compounds in the formation of Copper oxide nanoparticles.

3.2. FTIR Spectroscopy

Fourier Transform Infrared Spectroscopy gives data of functional group in leaves extract that interact with metal oxide and also gives the information about Cu-O bond. The identification of functional groups leads to determine the reducing agent and the capping agent responsible for synthesis and stability of metal oxide nanoparticle.

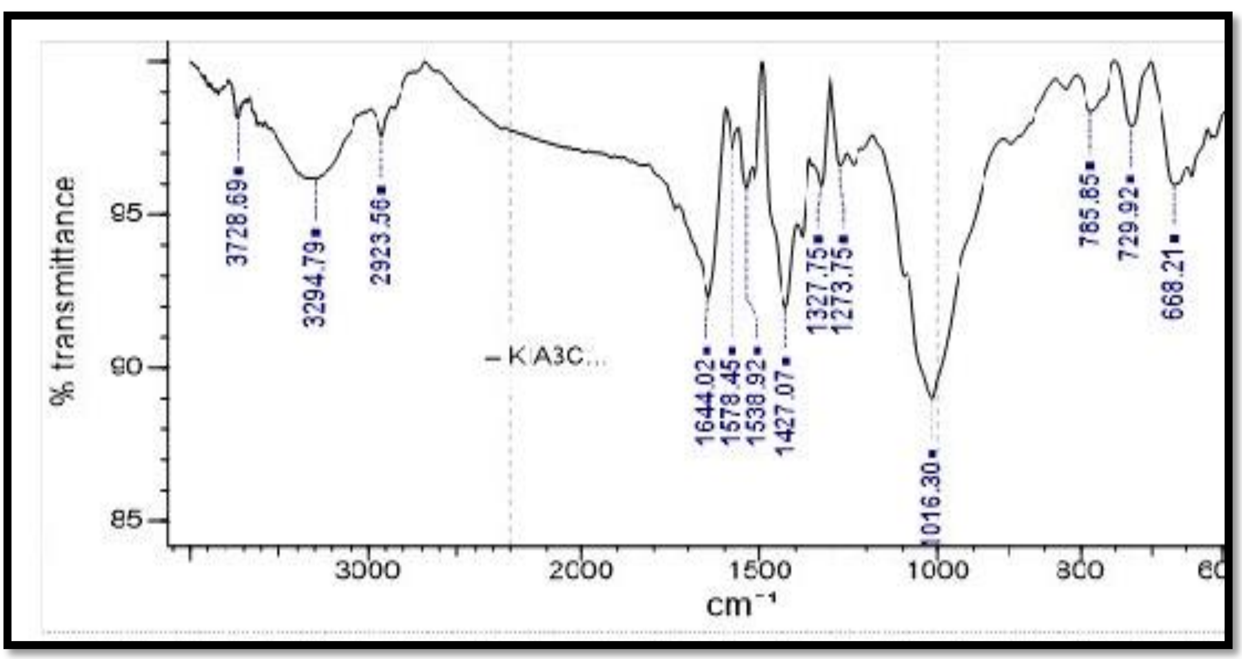

Fig. 3.2(a).FTIR spectrum of *Musa acuminata* leaves extract

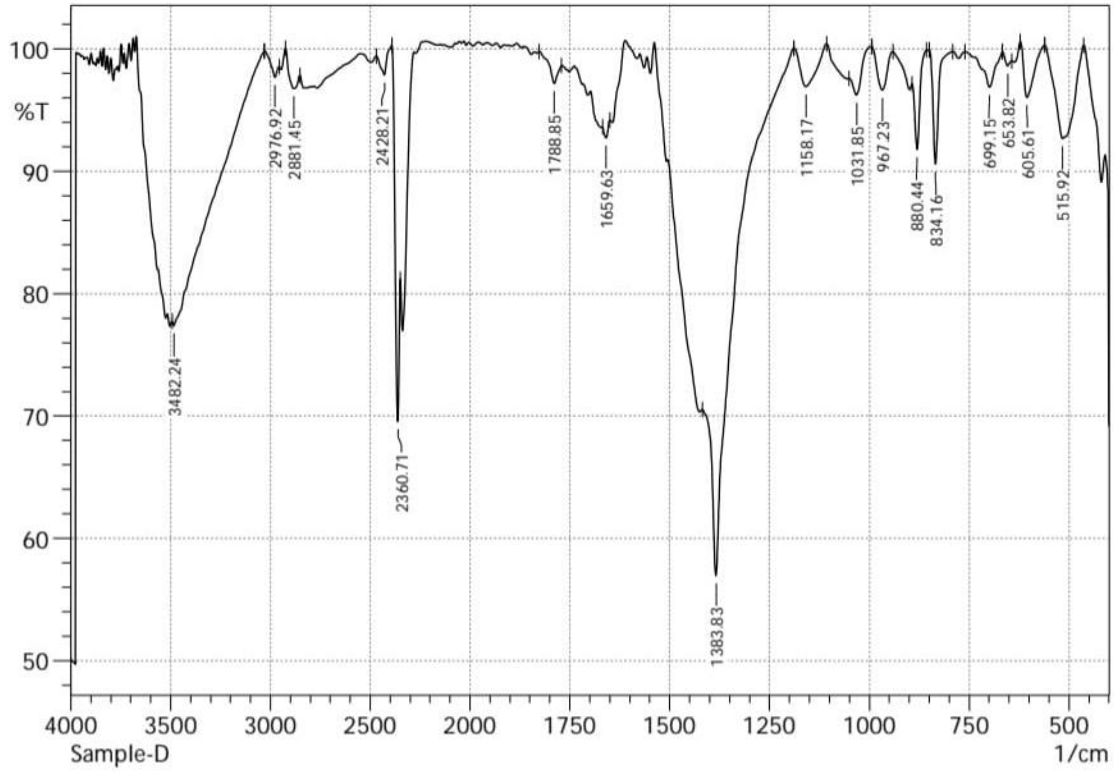

Fig. 3.2(b). FTIR spectrum of CuO NPs synthesized using *Musa acuminata* leaves extract

Wavenumber(cm^{-1})		Functional group(s)
CuO Nps Synthesized using *Musa acuminata* Leaves Extract	***Musa acuminata*** Leaves Extract	
3482.24	3728.69	O-HStretch of Phenolic Compound
2976.92	2923.56	C-H Stretch of alkene
1659.63	1644.02	C=O group
1383.83	1327.75	-C-O Group
834.16	785.85	-C-H (Out of plane bending)
605.61	668.21	Aromatic -C-H Strech
515.92	_	Cu- O

Table 1: Frequency Interpretation Data of FTIR spectra

The FTIR spectrum of *Musa acuminata* leave extract shown in Fig.3.2.(a).The peak at 3728.69cm^{-1} indicates the presence of O-H stretch of phenolic compound.(10) The peak at 2923.56 cm^{-1} is due to the presence of O-H stretch of alkene. The peak at 1427.07 $cm^{-1}$is due to the presence of C=O group. The peak at 1327.75 cm^{-1} is due to the presence of –C-O Group. The peak at 785.85 cm^{-1} is due to the presence of –C-H (Out of plan bending).The peak at 668.21 cm^{-1} is due to the presence of Aromatic –C-H Stretch.

The FTIR spectrum of CuO nanoparticles using *Musa acuminata* leaves extract shown in Fig.3.2.(b). The peak at 3482.24 cm^{-1} indicates the presence of O-H stretch of phenolic compound. The peak at 2976.92 cm^{-1} is due to the presence of O-H stretch of alkene. The peak at 1659.63 cm^{-1} is due to the presence of C=O group . The peak at 1383.83 cm^{-1} is due to the presence of –C-O Group. The peak at 834.16 cm^{-1} is due to the presence of –C-H (Out of plan bending).The peak at 605.61cm^{-1} is due to the presence of Aromatic –C-H Stretch .The peak at 515.92 cm^{-1} is due to the presence of Cu-O.

3.3. X-Ray Diffraction Analysis (XRD)

X-ray diffraction (XRD) measurements was carried out to confirm the crystalline structure, phase composition and preferential orientation of formed Copper oxide nanoparticles. The XRD pattern for CuO NPs is shown in fig 3.3.

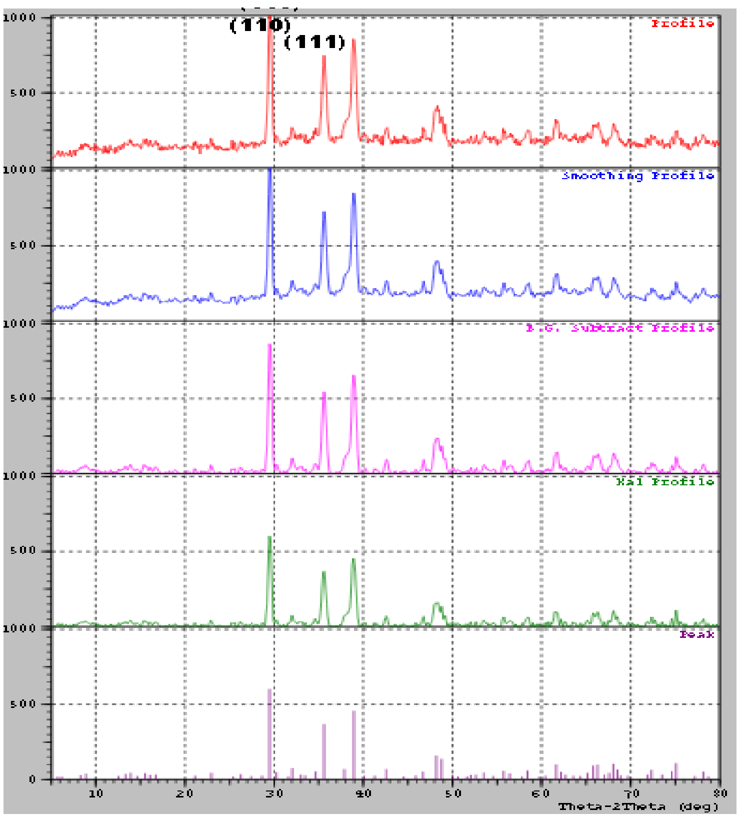

Fig.3.3.XRD pattern of synthesized Copper oxide nanoparticles using *Musa acuminata* leaves extract

From the Fig.3.3. It is seen that the XRD peaks appear at 29.5149^{0}, 35.5923^{0} corresponds to the (110), (111). This indicate FCC crystal nature of CuO nanoparticles. The XRD pattern of CuO nanoparticles clearly shows the crystalline nature [11].

2Θ	Θ	Cos Θ	FHWM β	FHWM (rad)	D (nm)
29.5149	14.757	0.9670	0.45940	0.007976	18.2
38.9333	19.466	0.9428	0.58420	0.010165	14.5
35.5923	17.796	0.9521	0.54190	0.009429	15.4

Table 2. Calculation of average particle size of CuO Nps using *Musa acuminata* Leaves Extract

It was found that the size of CuO NPs synthesized by *Musa acuminata* leaves extract was in the range between 14.5 to 18.2 nm.

3.4. Scanning Electron Microscopy

The surface morphology of the Copper oxide nanoparticles was studied by Scanning Electron Microscopy(SEM) analysis.

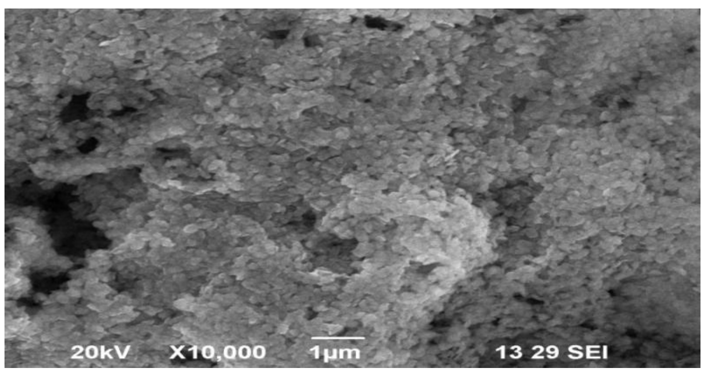

Fig.3.4. SEM image of CuONPs synthesized using *Musa acuminata* using leaves extract.

The Fig.3.4.shows the SEM image CuO NPs synthesized by the *Musa acuminata* leaves extract. It shows a spherical shape of Nanoparticles. This shape of the CuONPs nanoparticles may be due to the functional group present in plant leaves extract which may act as structure directing agent.

3.5. Energy Dispersive X-Ray analysis (EDX)

Energy dispersive X-Ray analysis was carried out to find out the elemental composition of the synthesized Copper oxide nanoparticles. The EDX graph of CuO NPs and the EDX data of CuO NP_S was shown in fig3.5. and the EDX data of CuO NPs was shown in Table 2. Indicate the Copper oxide nanoparticle synthesis using *Musa acuminata* leaves extract.

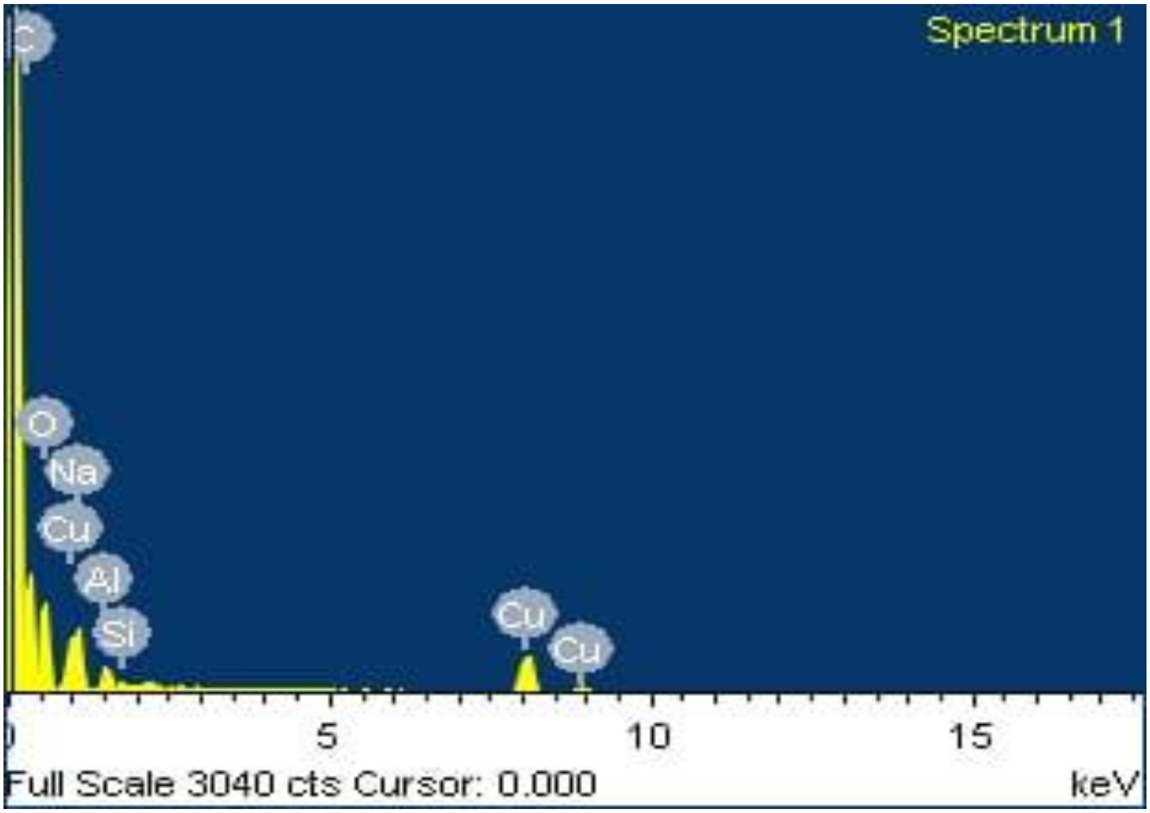

Fig.3.5. EDX graph of CuO NPs Synthesized from *Musa acuminata* leaves extract

Element	App Conc.	Intensity corrn	Weight%	Weight%	Atomic%
C K	9.62	0.6035	40.42	1.51	55.37
O K	8.25	0.6484	32.31	1.19	33.22
Na K	1.99	0.6537	7.74	0.52	5.54
Al K	0.47	0.6537	1.83	0.17	1.12
Si K	0.16	0.7458	0.53	0.12	0.31
Cu K	5.33	0.7878	17.17	0.79	4.45

Table 3. EDX data of CuO NPs synthesized from *Musa acuminata* leaves extract

EDX analysis proves the presence of elemental composition of Cu and O. The presence of other elements such as Na, Si, Al may be due to impurities.

Conclusion

The Copper oxide nanoparticles was successfully synthesized by using the leaves extract of *Musa acuminata* which provides cost effective, easy and proficient method for synthesis of CuO NPs. The blue shift in wavelength 394 nm indicates the smaller size of nanoparticle was confirmed by UV-VIS spectrophotometer. The metal-oxide bond was confirmed by FTIR analysis. XRD data clearly showed the crystalline nature of Copper oxide nanoparticle. SEM analysis confirmed the morphology of Copper oxide nanoparticle.

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