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KOLHAPUR

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A Project Work

**“A plant mediated synthesis of CuO nanoparticles
and its application”**

**Submitted to,
DEPARTMENT OF CHEMISTRY
Vivekanand College, Kolhapur (Autonomous)**

**For partial fulfillment of practical course for
The Award of M.Sc. Degree in Chemistry**

**By,
Miss. Shivani Sanjay Nakate
Miss. RutujaShubhash Desai
Miss. UtkarshaKrishnatYadav**

**GUIDE
Dr.Mrs.S.D.Shinde**

2022-2023



KOLHAPUR

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DEPARTMENT OF CHEMISTRY

CERTIFICATE

This is to certify the Miss. Shivani Sanjay Nakate, Miss. RutujaShubhash Desai and Miss. UtkarshaKrishnatYadav of class M.Sc.II has satisfactorily completed the project work on title "A plant mediated synthesis of CuO nanoparticles and its application" as a partial fulfillment of the practical course for the award of M.Sc. Degree in Chemistry by Shivaji University, Kolhapur.

Place: Kolhapur
Date: / /2023

**Dr.Mrs.S.D.Shinde Examiner
Project Guide**




Head Of Department

DECLARATION

It is hereby declared that work reported in project entitled "A plant mediated synthesis of CuO nanoparticles and its applications" is completed and written by us and has not copied from anywhere.

Place: Kolhapur

Date: / / 2023




Sr.No.	Name of Student	Roll No.	Sign
1	Miss. ShivaniSanjayNakate	370	
2	Miss. RutujaShubhashDesai	362	
3	Miss. UtkarshaKrishnatYadav	377	

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I extend my sincere thanks to all the faculty members as well as the non-teaching staff of the Chemistry Department for their Co-operation.

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Sr.No.	Name of Student	Roll No.	Sign
1	Miss. ShivaniSanjayNakate	370	
2	Miss.RutujaShubhashDesai	362	
3	Miss.UtkarshaKrishnatYadav	377	

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1.INTRODUCTION

1.1 Nano Materials:

The prefix Nano means one billionth. One nano meter is 1/1,000,000,000 of a meter. Nanometer is designated as nm. (1nm= 10^{-9} meter). To aware of a nanoscale, let us consider the following facts

- i. Human hair is structures of the particles or material at least one dimension roughly between 1 to 100 nanometers. The structures are called as nanostructures and the substances or the material of this size may be called as nanomaterial. "Nano technology mainly consists of processing, separation, consolidation of about 50,000 nm.
- ii. DNA strand is roughly of 2 nm wide.
- iii. A typical atom is about 0.1 to 0.2 nm.
- iv. Just ten hydrogen atoms placed in a line will make up 1 nm.

Nano technology is the branch of science which study the fundamental principles of molecules and, deformation of materials by one atom or by one molecule."

Nano materials are cornerstones of Nano science and nanotechnology. Nanostructure Science and technology is a broad and interdisciplinary area of research and development activity that has been growing explosively worldwide in the past few years. It has the potential for revolutionizing the ways in which materials and products are created and the range and nature of functionalities that can be accessed. It is already having a significant commercial impact, which will assuredly increase in the future. PbS is a direct narrow gap semiconductor very suitable for infrared detection Applications. At room temperature, its energy band gap is approximately 0.37–0.4 eV [1]. This material has also been used as photo resistance, diode lasers, humidity and temperaturesensors, decorative coatings and solar control coatings, among others applications [2]. For these reasons, many research groups have an increasing interest in the development and study of this material.

1.2 History:

The history of nano materials is too long. Nano materials were prepared and used in 19th Century. Decorative coloured glass windows which were used in old Churches and Palaces had used nanoparticles of iron, nickel, cobalt, silver, gold etc. Michael Faraday in 1857 has prepared stable colloidal solution of gold having particles of Nano size. [4] Photographic plates were covered by silver halide nano particles. But in those days due to lack of powerful microscope or other devices the size of the particle was remained unknown.

Nobel-Laureate and physicist Richard Feynman in his famous speech given at American physical society on December 29, 1959, "There is a plenty of room at the bottom." He pointed out to the scientists that Nano size material can have tremendous applications and can exhibit quite different properties.

The progress of Nano science and nanotechnology took place in last three decades. The invention of scanning Tunneling Microscope by Binnig and Rohrer in 1981 who shared 1986 Nobel Prize in Physics showed that the images to the atomic size are possible. After a decade in 1990 Don Eigler and Erhard Shucizer at the IBM Almaden Research Laboratory have discovered that, the Scanning Tunneling Microscope Tip can be used to move and position a single atom or molecule, on the surface. They positioned Xenon atoms on Nickel surface by Scanning Tunneling Microscope Tips[5]. This was the milestone in advancement of science and proved that atomic manipulation is possible.

In 1985 Curl, Kroto and Smalley synthesized sixty atoms carbon molecule later named is Fullerene. They were awarded 1996 Nobel prize in Chemistry. In 1991, Iijima discovered carbon- nanotubes. In 2004, British Scientist Gem and Nevoelve discovered another allotrope of carbon named Graphene and for this discovery they were awarded 2010 Nobel Prize in Physics.

When dimension of material is reduced below 100 nm, then its mechanical, thermal, optical magnetic and other properties change than larger size properties of that material. Gold solution can be orange, purple green depending upon particle size. Due to smaller size larger surface area nano particles exhibit interesting and astonishing properties [3].

1.3 Introduction to Copper oxide (CuO):

1.3.1 General Introduction to CuO:

Copper(II) oxide is the inorganic compound with the formula CuO. A black solid is one of the two stable oxide of copper, the other being cuprous oxide. As a mineral, it is known as tenorite and paramelaconite. Copper (II) oxide belongs to the monoclinic crystal system. The copper atom is coordinated by 4 oxygen atoms in an approximately square planer configuration.

Copper oxides exist in two stable forms, the cuprous oxides Cu₂O and the cupric oxides CuO. These two oxides have very different colors, crystal structures, and physical properties. Simple chemistry tells that these differences are mainly due to the fact that Cu in Cu₂O is in the Cu⁺ state.

Cu₂O is a red-colored cubic semiconductor that displays a wealth of interesting excitonic levels. CuO on the other hand has a dark, iron gray color and crystallizes in a more complicated monoclinic tenorite structure exhibiting interesting antiferromagnetic ordering. CuO has also known as p-type semiconductor that exhibits a narrow band gap (1.2 eV) [6]. Due to the appearance of high T_c superconductors of CuO materials, it has received much attention since 1986. Their superconductivities are controlled by the structure, composition and the type and density of carriers. It also exhibits other interesting properties. For example, monoclinic CuO solid belongs to a particular class of materials known as Mott insulators, whose electronic structures cannot be simply described using conventional band theory.

Recent studies by several groups indicate that it could exist in as many as three different magnetic phases. It was a 3D collinear antiferromagnet at temperatures below 214 K. When the temperature was raised, it first became an intermediate noncollinear incommensurate magnetic phase up to 230 K and then acted like a 1 D quantum antiferromagnetic material. The temperature dependent dielectric constant of polycrystalline CuO exhibits a striking feature of very high dielectric constant ($\sim 2 \times 10^4$) comparable to those of the recently reported high dielectric materials CaCu₃Ti₄O₁₂ (CCTO) and Li and Ti doped NiO (LTNO) ceramics. With regard to its commercial value, it has been widely exploited for use as a powerful heterogeneous catalyst to convert hydrocarbons completely into carbon dioxide and water. It is also

potentially useful in the fabrication of lithium-copper oxide electrochemical cells [7]. Recently found that it is useful for supercapacitor application [8].

It is widely used as an additive in numerous materials and products including rubbers, plastics, paints, ceramics, glass, cement, ointments, adhesives, foods, batteries, fire retardants and first-aid taps. Although it occurs naturally as the mineral Cuprite, most copper oxide is produced synthetically.

1.3.2 Crystal Structure of CuO:

The CuO has a considerably more complicated tenorite structure, similar to AgO [9]. The monoclinic unit cell (space group C_{2h}^6) contains four molecules. The crystal parameters were measured to be $a=4.6837 \text{ \AA}$, $b=3.4226 \text{ \AA}$, $c=5.1288 \text{ \AA}$, and $\beta=99.54^\circ$. The coordination of atoms in CuO is such that each ion has four nearest neighbors of the other kind. In the (110) plane, each Cu atom is linked to four nearly coplanar O atoms at the corner of an almost rectangular parallelogram. The Cu-O bond lengths in this plane are 1.88 and 1.96 \AA , respectively, which are larger than those in the cuprous oxide. The next to Cu-O bond lengths perpendicular to the plane are much greater, so an octahedral type of coordination can be ruled out. The O atom is coordinated to four Cu atoms in the form of a distorted tetrahedron. It is generally believed that the bonding in CuO is a mixture of ionic and covalent bonding, although the oxidation state of Cu in CuO is unquestionably Cu^{2+} .

The transition-metal monoxides such as CoO and NiO, on the other hand, crystallize in the rocksalt structure with much higher symmetry. Thus, this may indicate a fundamental difference in electronic states between the CuO crystal NiO or CoO crystal [10].

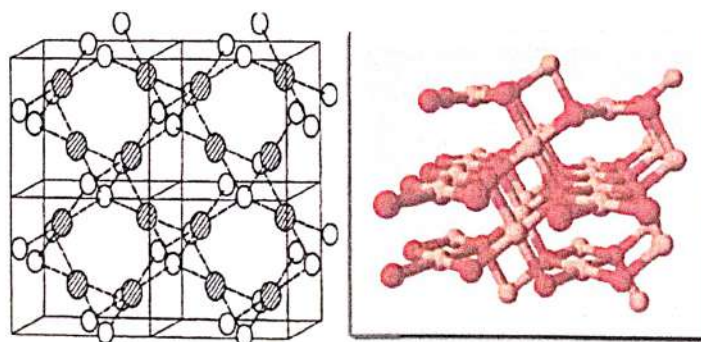


Fig.1.1 Crystal structure of monoclinic CuO and Unit cell structure of CuO.

1.3.3 Band structure of CuO:

Copper (II) oxide is a p-type semiconductor, with a narrow band gap of 1.2 eV and a variety of chemo physical properties, is recently attractive in many fields such as energy conversion, optoelectronic devices, dry cell batteries and catalyst.

Semiconductor can absorb light with energy higher than certain energy thresholds that is determined by the band gaps of semiconductor. Once photons are absorbed, photoelectrons and photoholes are formed. The photogenerated electrons and holes are quickly relaxed to the bottom of the conduction and top of the valence band respectively by dissipating their kinetic energy. The basic parameters of CuO is shown in Table 1.1.

Chemical Formula	CuO
IUPAC Name	Copper (II) Oxide
Molar Mass	79.545 gm/mol
Appearance	Black to brown powder
Density	6.315 gm/cm ³
Band Gap	1.2 eV
Refractive Index	2.63
Melting Point	1599 K
Boiling point	2270 K
Solubility in water	Insoluble
Solubility	Soluble in Ammonium Chloride, Potassium Cyanide Insoluble in Alcohol, Water, Ammonium Hydroxide

Table 1.1: Basic materials parameters of CuO.

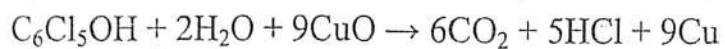
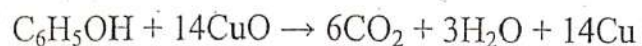
1.3.4 Uses:

As a significant product of copper mining, copper (II) oxide is the starting point for the production of other copper salts. For example, many wood preservatives are produced from copper oxide. Cupric oxide is used as a pigment in ceramics to produce blue, red, and green, and sometimes gray, pink, or black glazes. It is also incorrectly used as a dietary supplement in animal to low bioactivity, negligible copper is absorbed. It is also used when welding with copper alloys.

Cupric oxide (CuO), having a variety of chemo physical properties, is recently attractive in many fields such as energy conversion, optoelectronic devices, and catalyst. It can be also used in anti-bacterial and anti-fungal action.

1.3.5 Use in Disposal:

Cupric oxide can be used to safely dispose of hazardous materials such as cyanide, hydrocarbons and halogenated hydrocarbons and dioxins through oxidations. The decomposition reactions of phenol and pentachlorophenol follow these pathways:



1.4 Introduction to Thevetia Peruviana:

Cascabela thevetia (syn: Thevetia peruviana) is a poisonous plant native throughout Mexico and in Central America, and cultivated widely as an ornamental. It is a relative of Nerium oleander, giving it a common name yellow oleander.



Thevetia Peruviana

1.4.1 Scientific Classification:

- Kingdom :Plantae
- *Clade:* Angiosperms
- *Clade:* Eudicots
- *Clade:* Asterids
- *Order:* Gentianales
- Family: Apocynaceae
- Genus: Cascabela
- Species: T. Peruviana

1.4.2 Botanical description:

- Botanical Name: Thevetia peruviana (Pers) Merrill
- Synonyms: Cascabela thevetia (L.) Lippold, Thevetia neriifolia Juss. Ex A. DC.
- Common Name: Mexican Oleander, Yellow Oleander, Lucky Nut, Pili karen
- Plant Family: Apocynaceae
- Plant Form: Tree
- Occurrence (Sectors): 1, 2, 4, 10, 17, 22, 26-30

- Occurrence (Special Areas): Indroda Park, Van Chetana Kendra, Aranya Van

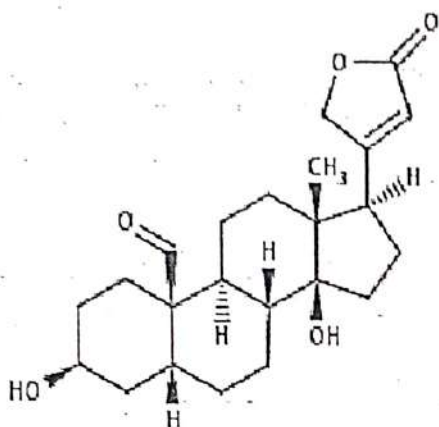
About Thevetia peruviana Plant:

- Habit: A small tree with milky juice.
- Leaves: Numerous, alternate, close together, linear, acute.
- Inflorescence: Axillary or terminal cymes
- Flowers: Yellow, fragrant, Calyx lobes 5, acute, imbricate, Corolla campanulate, segments 5, twisted imbricate, Stamens 5, in the throat of the corolla-tube, filaments hairy at base, anthers ovate, Disk angular, annular, thick, Carpels 2, connate, superior, style filiform, stigma big, capitate.
- Fruit: A fleshy drupe, 4 angled, compressed with 2 ridges, seeds 2 to 4.
- Flowering and Fruiting Time: Throughout the year.
- Significance: Common, wild and cultivated in the gardens. The whole plant is poisonous. Commonly planted near the temples, the flowers being offered to God Shiva. Seeds kept in the pocket for luck

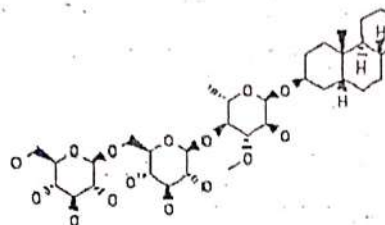
1.4.3 Chemical composition:

The flowers of *Thevetia Peruviana* contains phytochemicals such as alkaloids, tannins, saponins, phenolics and flavonoids. They contain cardiac glycosides. Many cases of intentional and accidental poisoning of humans are known. The toxins are cardenolides called Thevetin A and Thevetin B (Cerebroside), others include Peruvoside, Neriifolin, Thevetoxin and Ruvoside. These cardenolides are not destroyed by drying or heating and they are very similar to digoxin from *Digitalis purpurea*. They produce gastric and cardio toxic effects. Antidotes for treatment include atropine and Digoxin antibodies and treatment may include oral administration of activate charcoal. Ovine polyclonal anti-digoxin Fab fragment antibody can be used to treat digoxin poisoning.

Structure Of Chemical Constituent



Thevetin B



Cannogenin

1.4.4 Green synthesis of nanomaterial:

Green protocols for the synthesis of nanoparticles have been attracting a lot of attention because they are eco-friendly, rapid, and cost-effective. Copper and copper oxide nanoparticles have been synthesized by green routes and characterized for impact of green chemistry on the properties and biological effects of nanoparticles in the last five years. Green synthesis, properties, and applications of copper and copper oxide nanoparticles have been reported in the literature. This review summarizes the synthesis of eco-friendly synthesis procedures. The use of ideal solvent systems and natural resources (such as organic systems) is essential to achieve this goal. Green synthesis of metallic nanoparticles has been adopted to accommodate various biological materials (e.g., bacteria, fungi, algae, and plant extracts). Among the available green methods of synthesis for metal/metal oxide nanoparticles, utilization of plant extracts is a rather simple and easy process to produce copper and copper oxide nanoparticles using different biological systems. This review also provides comparative overview of influence of chemical synthesis and green synthesis on structural properties of copper and copper oxide nanoparticles and their biological behavior. It concludes that green methods for synthesis of copper and copper oxide nanoparticles are better than chemical synthetic methods.

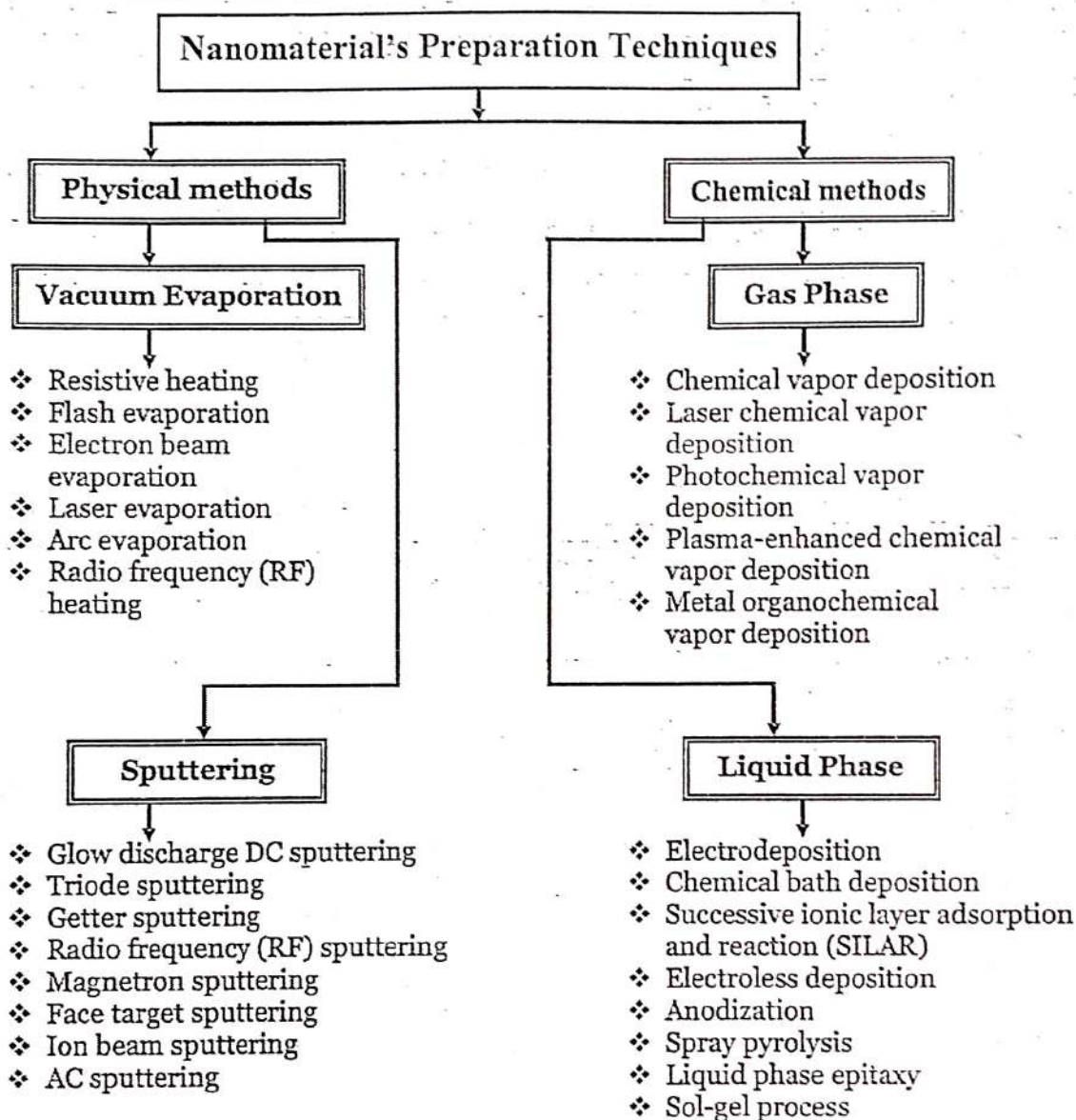
In materials science, “green” synthesis has gained extensive attention as a reliable, sustainable, and eco-friendly protocol for synthesizing a wide range of materials/nanomaterials including metal/metal oxides nanomaterials, hybrid materials, and bioinspired materials. As such, green synthesis is regarded as an important tool to reduce the destructive effects associated with the traditional methods of synthesis for nanoparticles commonly utilized in laboratory and industry. In this review, we summarized the fundamental processes and mechanisms of “green” synthesis approaches, especially for metal and metal oxide [e.g., gold (Au), silver (Ag), copper oxide (CuO), and zinc oxide (ZnO)] nanoparticles using natural extracts. Importantly, we explored the role of biological components, essential phytochemicals (e.g., flavonoids, alkaloids, terpenoids, amides, and aldehydes) as reducing agents and solvent systems. The stability/toxicity of nanoparticles and the associated surface engineering techniques for achieving biocompatibility are also discussed. Finally, we covered applications of such synthesized products to environmental remediation in terms of antimicrobial activity, catalytic activity, removal of pollutants dyes, and heavy metal ion sensing.

Green synthesis are required to avoid the production of unwanted or harmful by-products through the build-up of reliable, sustainable, and econanoparticles at large scale relative to bacteria and/or fungi mediated synthesis. These products are known collectively as biogenic nanoparticles.

Although significant works had been reported on using various plant-based extracts to formulate several metal oxide nanoparticles, the use of *Thevetia Peruviana* plant extract mediated biosynthesis of CuO nanoparticles explicitly is not seen in literature. Present work reports the green synthesis CuO NPs by using *Thevetia Peruviana* as green reducing and capping agent for the first time to our knowledge. The crystal structure, surface morphology, and sizes are characterized by using UV-Visible spectroscopy, XRD, SEM, FTIR techniques. The efficiency of CuO nanoparticles as catalyst for the various organic reactions is studied. We also carried out antimicrobial test of the biosynthesized copper nanoparticles.

2. SYNTHESIS AND CHARACTERIZATION OF TECHNIQUES

2.1. Classification of Nanomaterial's Preparation Techniques:



Nowadays, there has been increasing demand for deposition of thin films for their wide range of potential applicability in the various fields of science and technological progress in modern society. A lot of efforts have been taken to obtain thin films of required properties such as thickness, texture, uniformity, adhesivity, orientation etc. for particular applications. Thin film properties such as structural, morphological, electrical, optical, electrochemical etc. of a given material are strongly dependent on the method of deposition, the substrate material, the substrate

temperature, rate of deposition, and background pressure [1]. Modern technology requires thin films for different applications [2]. The application and properties of a given material which determine the most suitable technique for the deposition of thin films. Thin films can be deposited by number of physical and chemical techniques and can be classified as shown in table 2.1.

2.2 Chemical Bath Deposition (CBD):

2.2.1 Introduction

It is a method to deposit thin films and nanomaterial; it can be employed for large-area batch processing or continuous deposition. In 1933 Bruckman deposited PbS thin film by chemical bath deposition (CBD) or solution grown method.

There has been an increasing interest during the last few decades in the synthesis of binary and ternary semiconducting chalcogenide thin films, because of the widespread applications in various fields of science and technology leading to a drastic cut in the cost of production of semiconductor devices. The growth of thin films is a thermodynamically non-equilibrium process, meaning that the same system may exhibit drastically different growth behavior under different deposition conditions (e.g., layer-by-layer growth at low deposition rates, the formation of three-dimensional islands at high deposition rates, etc.). In the thin film formation, the properties are strongly dependent on preparatory technique used. Among the various deposition techniques, the CBD is a low temperature soft method for the growth of thin films.

The CBD method uses a controlled chemical reaction to effect the deposition of a thin film by precipitation. In a typical experiment, substrates are immersed in an alkaline solution containing the chalcogenide source, the metal ion and added base. A chelating agent is also added to control the release of the metal ion. The process relies on the slow decomposition of chalcogen source into Se^{-2} ions in an alkaline solution in which the free metal ion is buffered at a low concentration. The free metal ion concentration is controlled by the formation of complex species. A large number of physico-chemical factors such as solubility product, super saturation,

type of precipitation, etc., control the growth of the deposit under a specified set of reaction conditions.

A CBD is also called as solution growth, controlled or arrested precipitation, electro less deposition etc. In CBD method, when cationic and anionic solutions are mixed together and if ionic product exceeds or become equal to the solubility product, precipitation occurs as ions combine on the substrate and in the solution to form nuclei. The method requires the presence of reagents that act as a source of chalcogen ions and complexation of metal ions of interest whose equilibrium stability provides a concentration of metal cation small enough to produce the controlled homogenous precipitation of the film on the solid substrate.

2.2.2 Reaction mechanism

The CBD involves two steps, nucleation and particle growth, and is based on the formation of a solid phase from a solution. In the CBD procedure, the substrate is immersed in a solution containing the precursors. This method depends upon parameters like bath temperature, pH of the solution, concentration and time.

2.2.3 Advantages

1. The method does not require sophisticated instrumentation.
2. It is applicable for large area deposition.
3. Electrical conductivity of the substrate materials is not an important criterion.
4. The deposition is easy even at low temperature and avoids the oxidation or corrosion of the metallic substrate.
5. An intimate contact between reacting solution and substrate gives pinhole free and uniform deposition.
6. Stoichiometry of the deposit can be easily maintained.
7. The process is slow that facilitates better orientation of crystallites with improved grain structure.
8. The method can be used to deposit a large number of metal chalcogenide.
9. As very dilute solutions are used in the process, the method offers minimum toxicity and occupational hazards.

3. EXPERIMENTAL WORK

3.1 Experimental Details:

All chemical were of AR grade and used without any further purification. The Copper sulphate, $\text{CuSO}_4 \cdot 6\text{H}_2\text{O}$ was used as Copper (Cu) source and freshly prepared powder of well sundried flower of the ueliapesuviona as a complexing agent.

3.2 Synthesis procedure and reaction mechanism of CuO nanoparticles:

3.2.1 Preparation of extract:

We use the powder of the ueliapesuviona plant flower. About 10 gm of flower was added to 250 ml deionised water and boil it to reduce quantity upto 200ml. The appearance of light green coloured solution was observed. Which settle down at room temperature. The formed precipitate was filtered and the obtained supernatant was stored in the refrigerator for further use.



Fig. 3.1 Experimental setup for flower extract

3.2.2 Synthesis of Nickeloxide (CuO) nanoparticles:

Required amount of precursor $\text{CuSO}_4 \cdot 6\text{H}_2\text{O}$ was dissolved in de-ionized water to prepare 0.5 N 100 mL solutions after stirring for some time. The 50 ml thevta pureviona plant extract was mixed with 50 ml precursor solution in equal ratio drop by drop with stirring. Then whole solution stirred for 15 min till the formation of a greenish coloured precipitate which is allowed to settle. The solution was filtered and finally washed 2- 3 times with distilled water and alcohol to remove impurities followed by drying at 100°C in an oven for 5 hr .



Residue of CuO obtained after annealing

4. RESULTS AND DISCUSSION

4.1 Characterizations:

Optical absorption measurement was performed in the wavelength range 350-1100 nm by using a UV-visible spectrophotometer (UV-1800, Shimadzu, Japan). The X-ray Diffraction (XRD) spectrum of the film was recorded using X-ray diffractometer (Bruker AXS Model D8 Advance X-ray Diffractometer) with Cu K α target having wavelength 1.542 Å.

The Fourier transform infrared (FT-IR) spectra of samples were collected using a Spectrum100 Perkin Elmer FT-IR spectrophotometer using pellets made by mixing the sample with KBr, to investigate the functional groups of the CuO nanoparticles.

4.2 Optical Absorption Study:

The room temperature optical absorption spectra of the CuONPs solution in the range of 380-1000 nm without taking into account scattering and reflection losses. Fig. 4.1 shows variation in the optical absorption with wavelength.

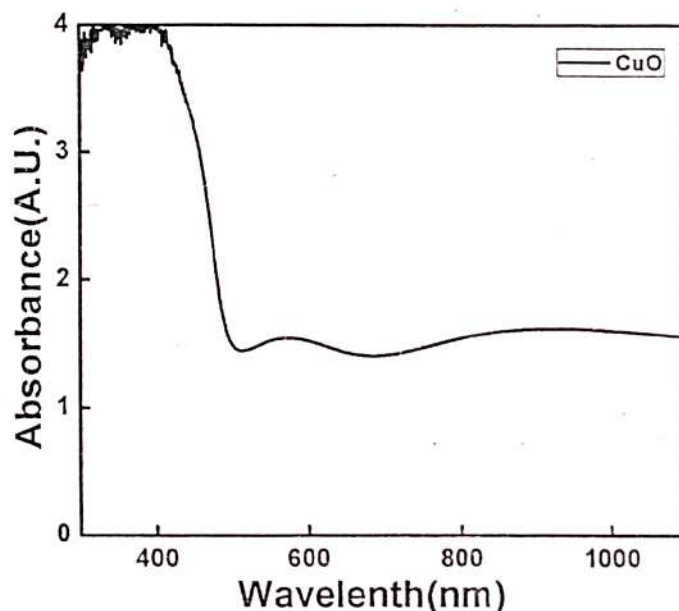


Fig. 4.1 Optical absorption spectra of CuO

The extrapolation of straight line portions to zero absorption coefficient ($\alpha = 0$), leads to the estimation of the band gap energy values which is found to be 2.1 eV due to quantum size effect. Quantum confinement leads to a collapse of the continuous

energy bands of a bulk material into discrete, atomic like energy levels. Thus, one observes an increase in the band gap of the semiconductor with a decrease in the particle size.

4.3 X-Ray Diffraction (XRD) Study:

The XRD patterns of the CuO thin films are shown in Fig. 4.2. The comparison of observed XRD patterns with the standard JCPDS data (Card no. 80-0076) confirms the formation of a CuO phase with monoclinic crystal structure.

The lattice parameters were calculated from XRD data is as follows, $a = 4.529 \text{ \AA}$, $b = 3.43 \text{ \AA}$, $c = 5.07 \text{ \AA}$. The CuO film exhibits XRD peak corresponding to (110) plane. Besides this major peak, nine more peaks corresponding to (111), (220), (202), (020), (113), (022), (420), (422) and (311) planes are observed. This suggests that, CuO phase is stable.

Further, the average crystallite size was calculated using a well-known Debye-Scherrer's formula:

$$D = \frac{0.9\lambda}{\beta \cos \theta} \quad 1$$

where, λ is the wavelength of X-rays (1.5406 \AA), β the full width at half maximum (in radian) of the peak, D is the diameter of the crystallite and θ is Bragg's angle of XRD peak. Further, the average crystallite size is estimated using Scherrer's formula is approximately 20.41 nm .

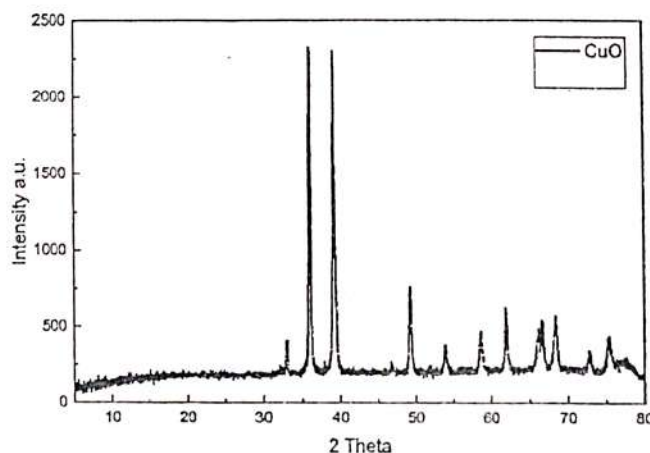


Fig. 4.2 X-ray diffraction pattern of the CuONPs.

4.4 Scanning Electron Microscopy (SEM) Study:

SEM study shows that CuO NPs having bulky nature with some smaller agglomeration. Average grain size was 50 nm.

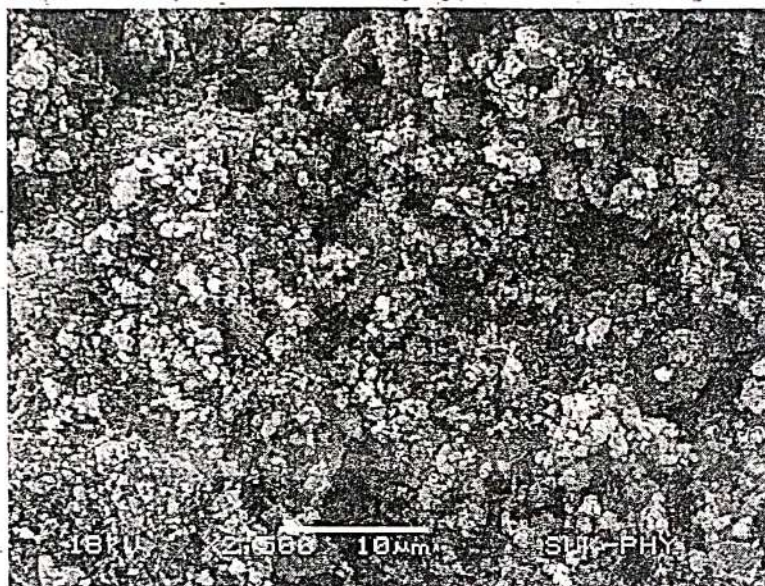


Fig. 4.3 SEM images of the CuONPs.

4.5 Fourier Transform Infrared (FT-IR) Spectroscopy:

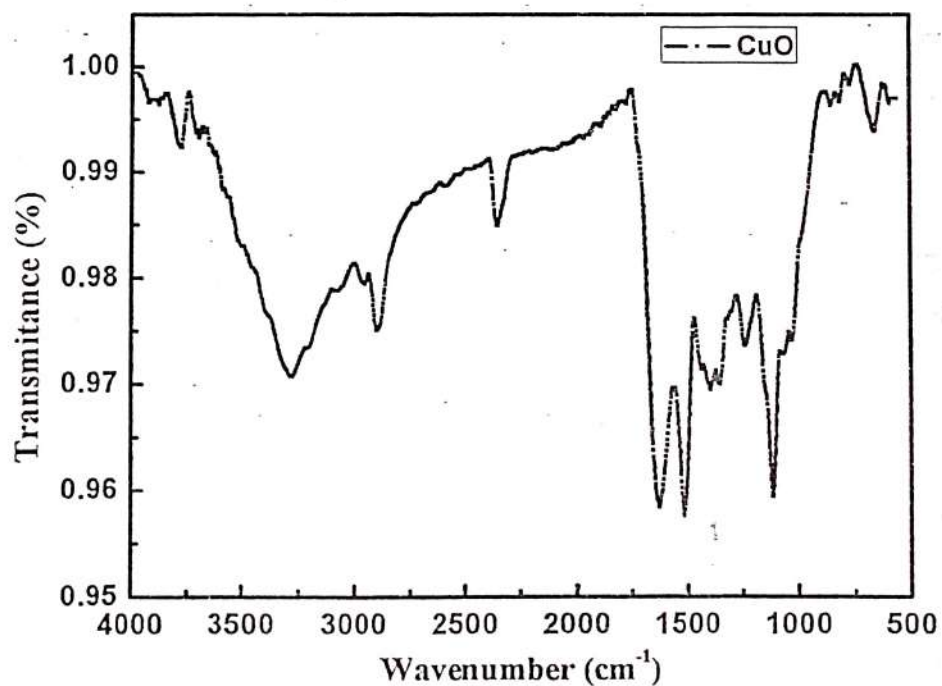


Fig. 4.4 FTIR transmission spectra of the CuO thin film was recorded in the wave number range of 550-4000 cm⁻¹.

FT-IR spectroscopy was carried out to identify the functional groups present in the *C. ternatea* which acts as reducing and capping agents of synthesized CuO NPs as shown in Fig. 4.3. The interaction of plant compounds with the chemical has shifted from weak to strong and broad peak at 3288 cm^{-1} due to water molecule, $2896\text{-}2977\text{ cm}^{-1}$ due to the alkyl group, 2350 cm^{-1} is the band arising from the absorption of atmospheric CO_2 on the metallic cations, 1624 cm^{-1} assigned to C=C aromatic stretch, 1533 cm^{-1} is the stretching mode of vibration corresponding to C=C, 1394 cm^{-1} assigned to C-H alkenes stretch, 1121 cm^{-1} assigned to C-N amines stretch, 758 cm^{-1} and 667 cm^{-1} assigned to C-H alkenes stretch and the peak observed at 577 cm^{-1} indicates the presence of CuO NPs.

5. Applications of Synthesized CuO nanoparticles

5.1 Introduction:

Synthesized nano particles are basic in nature. There are some reports of multicomponent organic synthesis catalyzed by CuO nanoparticles. We have decided to apply for anti-bacterial and anti-fungal activity and catalytic activity on reaction

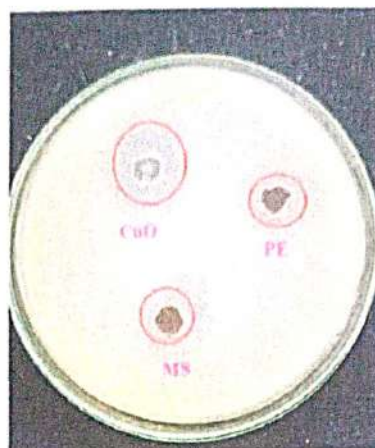
5.2 Application for Anti-bacterial and anti-fungal activity:

The antibacterial activity of the synthesized copper oxide nanoparticles using *Clitoria ternatea* plant seed extract was examined against *Bacillus* bacteria by using disc diffusion test.

Briefly Luria Bertani (LB) broth/agar medium was used to cultivate bacteria. Fresh overnight culture of inoculums (100 L) of each culture was spread on to Mueller Hinton Agar (MHA) plates. Sterile paper disc of 5mm diameter containing 30 g/mL CuO NPs along with standard antibiotic (30 g/mL) containing discs was placed in each plate as control. The plates were incubated at 37°C overnight. Next day the inhibition zones around the discs were measured.

The inhibitory activity of CuO nanoparticles is carried out on Bacteria (*Bacillus*) organism. The radial diameters of the inhibition zone of Plant extract (PE), metal Salt (MS) and CuO NPS are summarized in the table below. For different concentrations of CuO NPs it shows different inhibitory activity. The inhibitory activity for CuO NPs is 11.43% in bacteria.

Element	Target organism	Activity
Bacillus (Bacteria)	CuO NPs	2.8
	Plant Extract	1.9
	Metal Salt	1.4

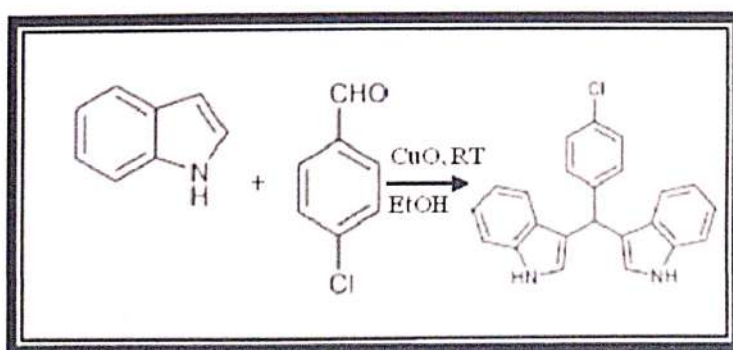


Antibacterial activity

5.3 Application as a catalyst in one pot synthesis :

The Prepared CuO nanoparticles are used as novel solid catalyst. The prepared catalyst was applied to the green and highly efficient synthesis of bis(indolyl)methanes. The reaction was carried out by using p-chlorobenzaldehyde (1 equivalent) and indole (2 equivalents) in presence 0.282 gm (1 equivalent) of CuO at room temperature in ethanol as a solvent. The reaction complete in 4 hrs. The desired product obtained is orange red coloured 3,3'-[(4-Chlorophenyl)]methylenebis-(1H-indole). The melting point observed is 79.0 °C. The obtained yield is 92 % approx.

The product is confirmed by melting point, and spectroscopic data obtained from NMR as given below.



Scheme 1: CuO nanoparticles catalyzed one pot synthesis of bis(indolyl)methanes.

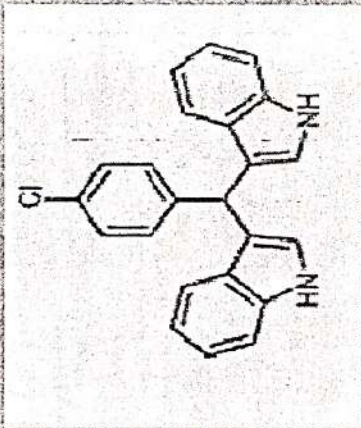
(3,3'-[(4-Chlorophenyl)methylene]bis(1H-indole) (Table 2, entry g). Pink solid, ¹H NMR (200 MHz, CDCl₃): δ 5.88 (1H, s), 6.63 (2H, brs), 7.00–7.70 (12H, m), 7.92 (2H, bs, NH)

SPECTRA

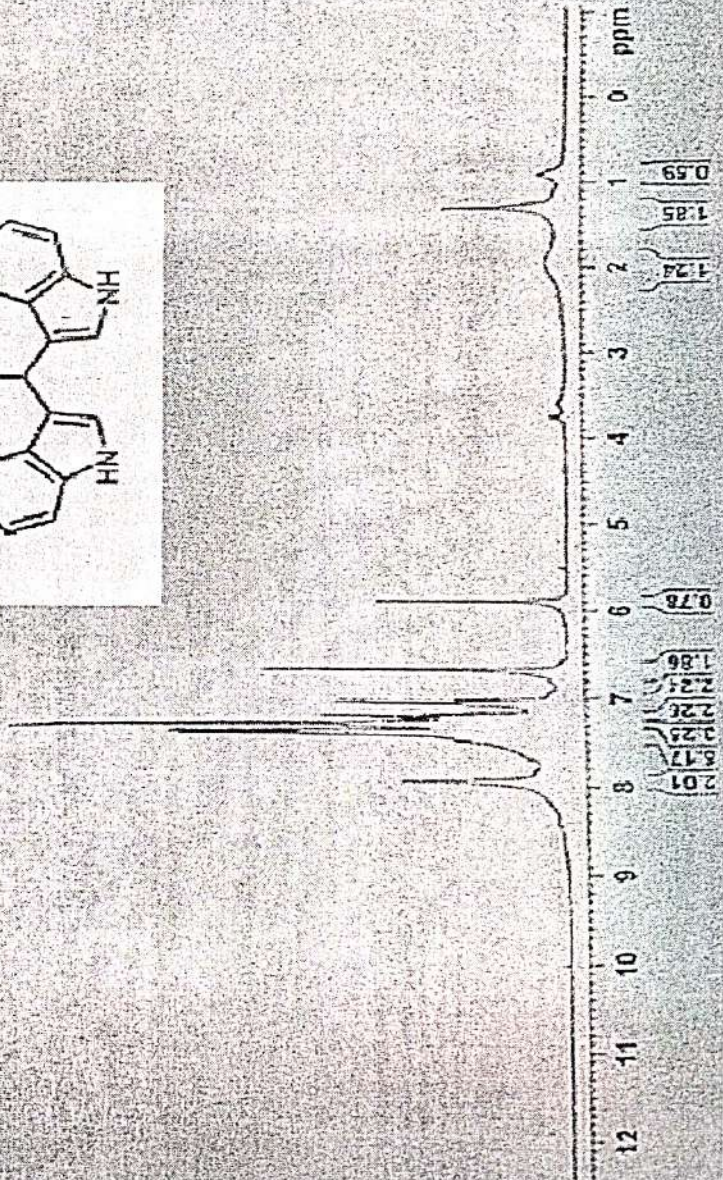


NAME: MAS
 TAHO: 706
 PFCNO: 1
 DATE: 2019072
 TIME: 12.13
 INSTR: spect
 PROBU: 5 mm BBO BB-H
 PULPROG: zgpg
 TO: 6582
 SOLVENT: CDCl3
 NS: 10
 DS: 2
 SWH: 6148.119 Hz
 FREQCZ: 0.09499717
 A0: 51251572.890
 RG: 257
 EN: 30.800 usec
 DE: 6.00 usec
 TE: 300.0 K
 PU: 1.00000000 usec
 TD: 1

CHANNELS: CLEANED, ZI, MIXTURE
 NUC1: 13C
 P1: 11.00 usec
 PL1: 0.00 dB
 FREQ: 101.625374 MHz
 SFO1: 100.625374 MHz
 SI: 32769
 SF: 300.1300600 MHz
 CH: C1
 CR: 0
 LG: 0.10 Hz
 GR: 0
 IN: 1.00



7.935
 7.931
 7.892
 7.851
 7.401
 7.375
 7.359
 7.289
 7.279
 7.279
 7.279
 7.246
 7.227
 7.203
 7.177
 7.058
 7.037
 7.013
 6.975
 6.897



6. CONCLUSIONS

We demonstrate a simple and low temperature strategy of chemical synthesis of CuO NPs. The XRD analysis gave the formation of polycrystalline CuO with monoclinic crystal structure. SEM study shows that CuO NPs having bulky nature with some smaller agglomeration. Existence of different peaks of CuO nanoparticles in FTIR revealed the formation of CuO and presence of different functional groups.

From the above results we can conclude that the prepared CuO nanoparticles show anti-bacterial activities. Hence CuO nanoparticles can be utilized in preparation of agrochemical, pharmaceuticals, dermatological creams and powders etc. Here we describes how CuO NPs mediated an efficient, rapid synthesis of bis(indolyl)methane in excellent yields at room temperature in shorter reaction times.

7. REFERENCES

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