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2.3.1 : Student centric methods, such as experiential learning, participative learning and problem solving methodologies are used for enhancing learning experiences

2022-23

SCHOOL OF ARTS AND SCIENCE

DEPARTMENT OF MICROBIOLOGY

Response:

PRIST University considers the adoption of student's centric methods to improve student participation as a part of participative learning and problem solving methodology.

- Team works,
- Debates,
- Seminar
- Quizzes and case studies

Specifically, Students centric Teaching Methods are reflected in project work, Field Visit, Industrial visit& guest lectures.

1. Experimental Learning:

Department conducts add-on courses to aid students in their hands-on education. The department encourages the following experiential learning techniques to raise students' levels of creativity and intelligence.

- ❖ Beyond the experiments in the syllabus, laboratory sessions are undertaken.
- ❖ Summer internships give students practical experience while they are employed by the company.
- ❖ Additional courses offered by NPTEL, Coursera, etc. on the latest technology
- ❖ Student projects using the newest technology, with working prototypes displayed during technical fests.
- ❖ Industrial Visits to give students hands-on learning opportunities while they're at the organization
- ❖ Students take interest and learn things via experiential learning.

2. Participatory Learning:

- ❖ Students engage in a variety of activities during this type of learning, including seminars, group discussions, wallpapers, projects, and skill-based add-on courses.
- ❖ The participation of students in activities that allow them to employ their specialized

technical and management abilities, such as

- ❖ Annual Tech Fest – It is organized every year for engineering students were selected projects are displayed at the larger platform.
- ❖ Regular Quizzes- Quizzes are organized for student participation at intra or inter college level.
- ❖ Seminar Presentation – Students develop technical skills while presenting papers in seminars.
- ❖ Presentation and publishing of papers in conferences and journals - The objective is to give them exposure to learn and imbibe new skills.
- ❖ MOOC Programs (NPTEL, ICT-IITK, SAP, COURSERA etc.)

3. Problem-solving methods:

University encourages students to acquire and develop problem-solving skills. For this, the department organizes expert lectures on different topics, participates in different technical tests and other competitions.

- ❖ In-house summer training with project development, Regular Assignments based on problems
- ❖ Mini Project development, Regular Quizzes, Case studies Discussion
- ❖ Class presentations, Debates

4. Student Seminars:

- ❖ The Student seminars are organized where in the papers are presented by students on contemporary topics to enrich their learning experience.

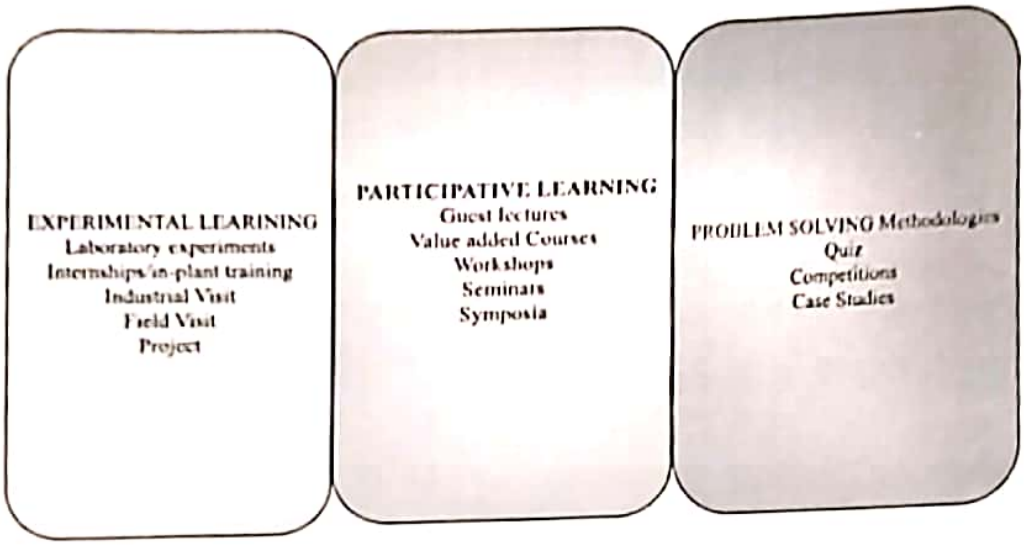
5. Black-board presentation:

- ❖ In this method, each student is given a certain question. And students have to solve this problem on the black-board.

6.ICT Enabled Teaching:

- ❖ ICT enabled teaching includes Wi-Fi enabled class rooms with LCD, Language Lab, Smart Class rooms, etc. The institution adopts modern pedagogy to enhance the teaching-learning process. The institution has the essential equipment to support the faculty members and students.

1. Methodology of students centric Teaching-Learning



1. Experimental Learning

1.1 Laboratory Experiments

S.No	Lab Name	List of Experiments
1.	22116AEC15L -Fundamentals of Microbiology Lab	1 Microscope and its operation 2 Cleaning of glassware's and sterilization methods – autoclaving and hot air oven 3 Preparation of culture media 4 Experimental demonstration of ubiquitous nature of microorganisms. 5 Quantitative estimation of microorganisms. 6 Observation of permanent slides to study the structural characteristics of algae(*Anabaena, Nostoc, Scytonema, Spirulina, Oscillatoria,)* Fungi (*Pythium, Rhizopus,* Saccharomyces, Penicillium, Aspergillus, Agricus) and protozoa (*Entamoeba hystolytica* and *Plasmodium* Spp*)* 7 Isolation of microorganisms from soil, water and air. 8 Test for motility of bacteria – Hanging drop method and semi solid media inoculation 9 Staining techniques – simple staining. Gram's staining, Spore staining, Capsular staining
2.	22116AEC25L- Microbial Physiology Lab	1. Bacterial culture / isolation techniques, a streaking method, b.Pour plate method 2. Isolation and cultivation of fungi 3. Bacterial growth curve: cell count / viable count / absorbance (total count) 4. Carbohydrate fermentation test: Glucose, Lactose, Maltose, Sucrose, Mannitol 5. Biochemical test for identification of Bacteria: Indole test ,Methyl red,Voges – Proskaur test, Citrate utilization, TSI agar test, Urease, Catalase,Oxidase
3.	22116AEC35L-Immunology Lab	1. ABO Blood Grouping 2. Rh typing 3. WIDAL Test 4. White Blood Cell Count 5. Red Blood Cell Count 6. Antigen preparation 7. Radial Immunodiffusion 8. Double Immunodiffusion 9. Demonstration of ELISA 10. Demonstration of RIA

4..	22116AEC46L - Virology Lab	1. Isolation of coliphage from sewage. 2. Determining Bacteriophage Titers 3. Cultivation of viruses in embryonated egg. 4. Chicks Embryo Fibroblast technique for virus cultivation
5.	22116AEC55L -Food and Dairy Microbiology and Molecular Biology Lab	1. Assessment of milk quality by methylene blue reduction test 2. Wet mount preparation of fungal organism from spoiled bread, tomato, grapes, potato. 3. Observation of food samples to *study Leuconostoc sp. Lactobacillus sp., Streptococcus lacti* and *Saccharomyces* 4. Preparation of yoghurt 5. Determination of thermal death time (TDT) and thermal death point (TIP) of microorganisms from spoiled foods 6. Direct microscopic examination of milk by standard plate count(SPC) method 7. Isolation of plasmid DNA from bacteria by Spectrophotometric assay. 8. Isolation of chromosomal DNA from bacteria by Spectrophotometric assay. 9. Development of competent cells in *E. coli.* 10. Isolation of antibiotic resistant auxotropic mutants. 11. Protoplast and Spheroplast isolation
6.	22116SEC65L - Clinical Microbiology Lab	1. Examination of parastic ova and cysts from faecal samples. 2. Identificaiton of pathogenic organism with a smear, culture and biochemical test 3. *Staphylococcus sp. E.coli, Klebsiella sp,*and *Salmonella typhi*

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Vallam, Thanjavur-613 403.

1.2 Student Internship

SPECIALTY LAB AND RESEARCH

UDYAM REGISTRATION MSME

Internship Certificate

This is to certify that Mr./Miss/Mrs.
LAVANYA A

(REG: 2001MB10214)
Has successfully completed Internship
In the area of "Microbiology Techniques" in this Laboratory from
24/August/22 to 03/September/22

03/September/2022
Date

Managing Director

SPECIALTY LAB AND RESEARCH

QUALITY MICROBIOLOGY CENTER

UDYAM REGISTRATION MSME

Internship Certificate

This is to certify that Mr./Miss/Mrs.
GOWSALYA J

(REG: 2001MB10208)
Has successfully completed Internship
In the area of "Microbiology Techniques" in this Laboratory from
24/August/22 to 03/September/22

05/September/2022
Date

Managing Director

Reg Office
Specialty Lab and Research
3rd Floor, Flat A, SVA Heritage Tower,
Lakshmi Nagar, Pudukkottai Main Road
Thanjavur - 613 005

Specialty Lab and Research

www.specialtylabandresearch.com

Head of the Department
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University, Thanjavur.

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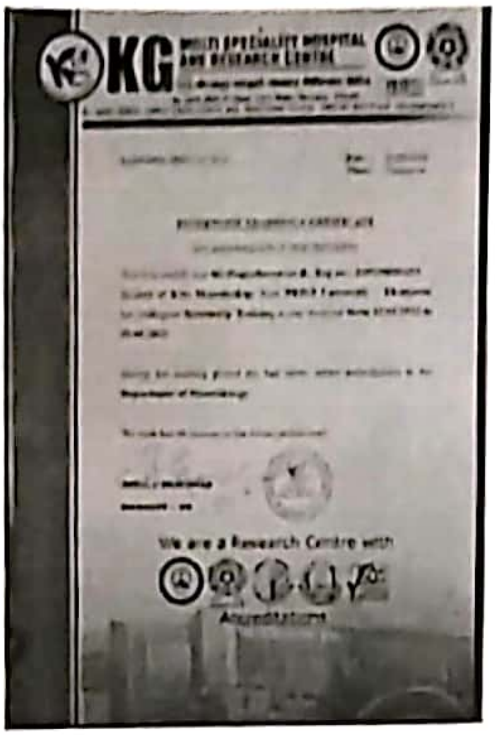

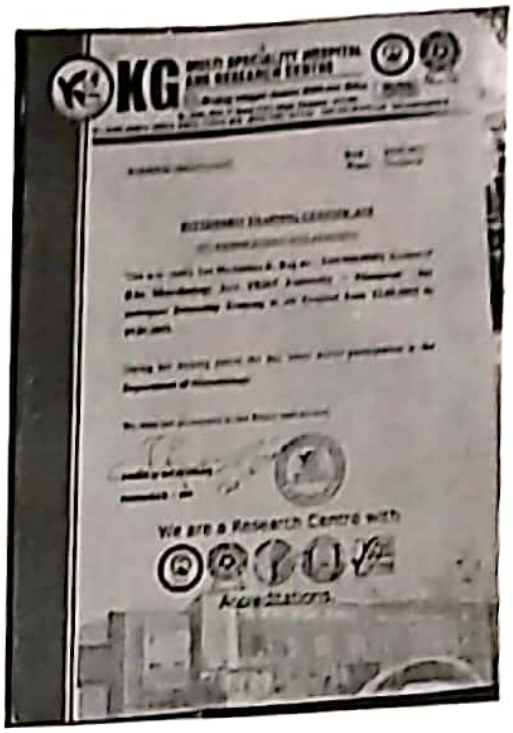

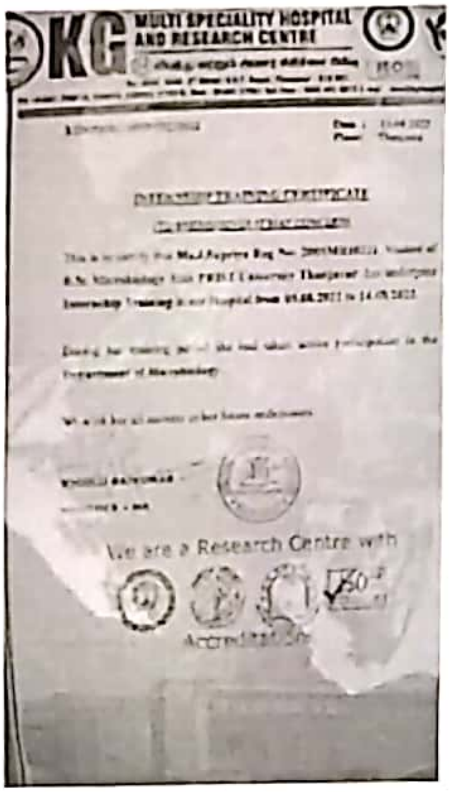

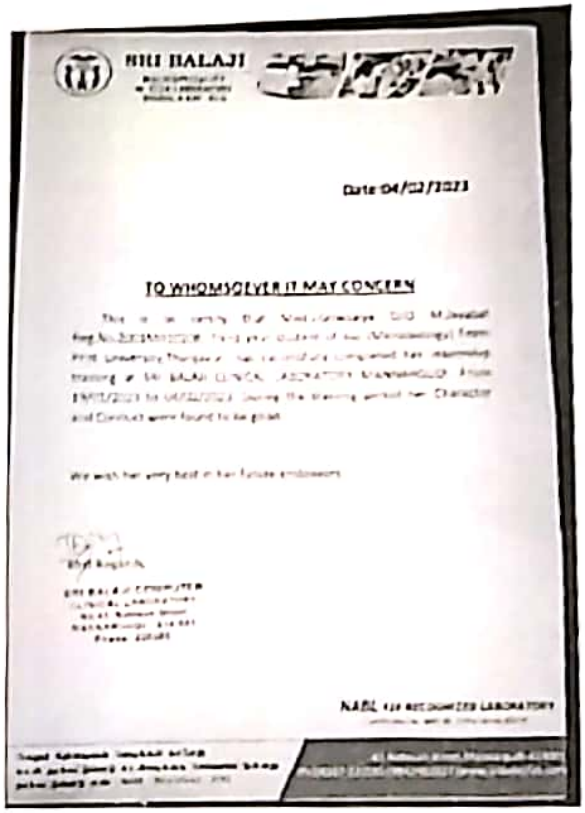

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Vallam, Thanjavur-613 403.

1.3Research work

BACHELOR OF SCIENCE

IN

MICROBIOLOGY

Submitted By

Dr. N. MAHALAKSHMI

COMPARATIVE STUDIES OF WINE PRODUCED FROM ... AND ... APPLE

BACHELOR OF SCIENCE

IN

MICROBIOLOGY

DEPARTMENT OF MICROBIOLOGY

SCHOOL OF ARTS AND SCIENCES

BACHELOR OF SCIENCE

IN

MICROBIOLOGY

S. THIYAGARAJAN

Dr. N. MAHALAKSHMI

A. Rafiudeen

Research Supervisor

Dr. R. Sathya

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June 2023

Head of the Dept.
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1.4 Field Visits

- Faculty identifies and propose Academically Significant Field visits and Surveys

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1.5 Industrial Visits

- Microbiology Departments Plan and Organize the industrial visits for students to provide exposure to industrial work culture.

Report

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SCHOOL OF ARTS AND SCIENCE
Department of Microbiology

INDUSTRIAL VISIT REPORT

Regional Extension Center COIR Board, Ministry of MSME, Govt. of India Thanjavur

Date: 13.10.2022

A complete report on industrial visit organized by Department Life Science School of Arts and Science, for the students of BSc I and II-year Microbiology, Biochemistry, Biotechnology (I sem and III semester) in order to get the practical knowledge about "advanced technology used in manufacture of Coir Fibre, Coir pith and Mats" carried out by Regional Extension Center COIR Board, Ministry of MSME, Govt. of India.

Index

DETAILS OF JOURNEY

50 students of First and Second Year Life Science, from Microbiology, Biochemistry, Biotechnology **attended on October 13, 2022.**

Head of the Department
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The visit was organized by **Dr.Bakruddin Ali Ahamed**, Professor, Department of Biochemistry and **Dr.S.Ambiga**, Associate Professor, Department of Biochemistry.

Dr.R. Sthaya, Assistant Professor, Department of Microbiology, Dr.N.Mahalakshmi, Assistant Professor, Department of Microbiology and Dr.J.Hamathi, Assistant Professor, Department of Biotechnology, School of Arts and Science were the coordinators Faculty for the industrial visit.

We started traveling from the college campus at 9:30 am via our college bus. Totally 58 students along with 4 coordinators faculty were there in the journey.

COMPANY PROFILE

COIR BOARD

Coir Board is the Nodal Agency for the SFURTI scheme. The coir Board set up by the Government of India under an act of parliament the coir Industry act 1953. Coir Board provides financial, market development, skill training assistance for the development of coir Industry and also extends the technical guidance and advice for setting up of new units as well as for renewal/modernization of existing units for development and 19 increasing productivity, quality up-gradation etc. A brief introduction about industry was given by PN.Sabu After that the plant head D.Kuppuramu was felicitated. Lastly, we ended the visit by clicking a group photograph at 12:30 PM and we moved out of the plant. Coir industry is of great importance to the coconut producing states in India, as it contributes significantly to the economy of rural areas. Kerala is the largest producer of coconut, contributing as much as 45% of country's total production, whereas Tamilnadu stands second in cultivation of coconut and first in production of brown coir fibre in the country. The major products that are exported are Coir Fibre, Coir pith and Mats.

OPPORTUNITIES:

- Potential for product diversification and value addition from existing products.
- Exploiting the individual investment potential for strengthening the value chain.
- would augment the prospects of the industry appreciably.

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- Increasing Domestic and Export market prospects for coir products.
- Good scope for manufacturing of value added /diversified products

THREATS:

Competition from products such as Nylon, Jute Sisal fibre etc. Competition from coconut growing country viz.: Sri Lanka, Indonesia & Philippines etc. Utilization of husk for fuel purposes.

GROUP OBSERVATION

- This Industrial visit is very helpful in our future practical Life & bring a positive change in our thinking & practical behavior regarding Education & specializing our technical skills.
- Got practical knowledge about the advancement in technology of COIR.
- Use of programming in field of Life Science
- Precise cutting and surface finishing of the jobs.
- Management of manpower and machines.
- Different courses offered by training section.
- Different types of machines available for Coir Fibre, Coir pith and Mats

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A. [illegible]
Head of the Department
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CONCLUSION

- We are thankful to all our faculties for organizing such an Informative event for us crucial for development of our practical skills regarding COIR, Good scope for manufacturing of value added /diversified products and other activities.
- We got the knowledge on different types of material used in COIR and had an opportunity to research it.
- We got knowledge in development of trained manpower and evolving and popularizing new designs and patterns for coir products, self-employment opportunities under PMEGP, job opportunity in coir industrial unit
- We hope to get more chances to have such informative & wonderful experiences of visiting different industries.

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2. Participative Learning
2.1 Guest lectures

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Consolidated Report on 'One Day SEMINAR ON "SECONDARY METABOLITES PRODUCTION" & BIOFUELS AS SAVIOUR OF EARTH"

Date: 07.10.2022

Organizer's: Dr. N.MAHALAKSHMI & Dr. A. XAVIER FERNANDES

Organized by

DEPARTMENT OF MICROBIOLOGY
SCHOOL OF ARTS AND SCIENCE
PRIST DEEMED TO BE UNIVERSITY
THANJAVUR, TAMIL NADU

Event organized: Department of Microbiology
ONE DAY SEMINAR ON SECONDARY METABOLITES PRODUCTION & BIOFUELS AS SAVIOUR OF EARTH
Report on ONE DAY SEMINAR ON SECONDARY METABOLITES PRODUCTION" & BIOFUELS AS SAVIOUR OF EARTH

Head of the Department
Department of Microbiology
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Dean
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Deemed to be University
Vallam, Thanjavur-613 403.

Introduction

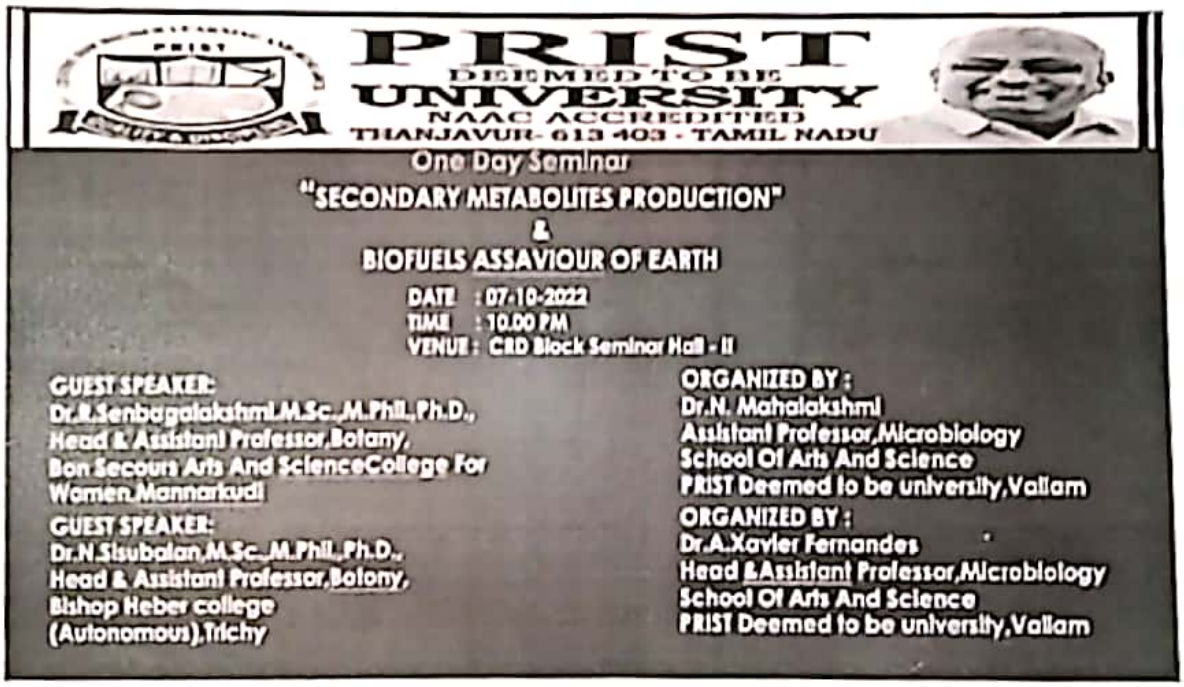
The purpose of this seminar is to provide elaborate knowledge to students for Functional microorganisms and health benefits represent a binomial with great potential for fermented functional foods. Moreover, title suggests, the health benefits of fermented functional foods are expressed either directly through the interactions of ingested live microorganisms with the host, Functional foods are a trend for industry for healthy eating and consumers' interest as a new alternative to prevent diseases such as allergies, intestinal problems and cardiovascular diseases.

High Lights:

- Fermented foods product
- Lactic acid bacteria
- Spirulina microalgae biomass

Organizing members

- Dr. R.Sathya
- Dr.T.Thiruselvi



Invitation

Head of the Department
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School of Arts and Science Department of Microbiology, Cordially invites to the one day seminar

On

07.10.2022 (Friday) 10.00 PM

Venue: Silver Jubilee Seminar Hall, CRD

Welcome address
Dr.S.Ambiga
HOD, Biochemistry, School of Arts and Science, PRIST Deemed to be University, Vallam

Presidential Address
Dr.L.Chinnappa
Dean, School of Arts and Science, PRIST Deemed to be University, Vallam

Special talk
Dr.R.Tamizh Selvan
Dean, Prist Schools of Engineering, PRIST Deemed to be University, Vallam

Introduction to the Chief Guest
Dr.N.MAHALAKSHMI
Assistant Professor, Microbiology,School of Arts and Science, PRIST Deemed to be University, Vallam

Invited Speaker
Dr. R. Senbagalakshmi, M.Sc., M.Phil., Ph.D.,
Head & Assistant Professor, Botany,Bon Secours Arts and Science College for women,
Mannarkudi-614001

"SECONDARY METABOLITES PRODUCTION"

Introduction to the Chief Guest
Dr.A. Xavier Fernandes
HOD & Assistant Professor, Microbiology, School of Arts and Science, PRIST University, Vallam

Invited Speaker
Dr. N. Sisubalan, B.Ed., M.Sc.,Ph.D.,
Head & Assistant Professor, Department of Botany, Bishop Heber College (Autonomous), Trichy

"BIOFUELS AS SAVE OUR LIFE"

Vote of Thanks
Dr. T. Thiruselvi
Department of Microbiology,School of Arts and Science,PRIST Deemed to be University, Vallam.

Department of Microbiology
School of Arts & Science
Thanjavur

Dean
School of Arts & Science
Ramalayan Ramajayam Institute of
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THANJAVUR - 613 403, TAMIL NADU

Date: 07.1.2022

CERTIFICATE OF ATTENDANCE

This is to certify that **Dr.R.Senbagalakshmi, Head & Assistant Professor,** Botany,Bon Secours Arts And ScienceCollege For Women,Mannarkudi has acted as a resource person in the One day seminar on **"SECONDARY METABOLITES PRODUCTION"** in Department of Biochemistry, School of Arts and Science, PRIST University, Thanjavur held on 07.10.2022.

Dean

School of Arts and Science,

PRIST University, Thanjavur

School of Arts & Science
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Head of the Department
Department of Microbiology
School of Arts & Science
Prist Deemed to be University, Thanjavur.

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Date: 07.1.2022

CERTIFICATE OF ATTENDANCE

This is to certify that **Dr.N.Sisubalan,** Head & Assistant Professor,Botony, Bishop Heber college (Autonomous), Trichy has acted as a resource person in the One day seminar on **"BIOFUELS AS SAVIOUR OF EARTH"** in Department of Biochemistry, School of Arts and Science, PRIST University, Thanjavur held on 07.10.2022.

Dean

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PRIST University, Thanjavur

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The Department of Microbiology had organized **ONE DAY SEMINAR ON "SECONDARY METABOLITES PRODUCTION & BIOFUELS AS SAVIOUR OF EARTH"** on 7th OCTOBER 2022. Welcome address given by Dr. S. Ambiga Head and Professor, Department of Biochemistry, Presidential address Dr. L. Chinnappa Dean, School of Arts and Science, PRIST University.

Head of the Department
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Special talk given by **Dr. R.Tamizh Selvan** Dean, School of Engineering, PRIST University respectively. Introduction to Chief Guests given by **Dr. N. Mahalakshmi &** **Dr. A. Xavier Fernandes,** Assistant Professor, Department of Microbiology, PRIST University. Two Lecturer given by the two resource persons first one is **Dr.R.Senbagalakshmi,** Head & Assistant Professor, Botany,Bon Secours Arts And Science College For Women,Mannarkudi, Title: **"SECONDARY METABOLITES PRODUCTION"** and the second one is **Dr.N.Sisubalan,** Head & Assistant Professor, Botany, Bishop Heber college (Autonomous), Trichy, Title: **"SECONDARY METABOLITES**

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Certificate of Appreciation

This is to certify that **Dr. P. Senbagalakshmi, Head & Assistant Professor** *from* **Department of Botany, Bon Secours College of Arts and Science for Women, Thanjavur** *has acted as a resource person in one day seminar on* **"Secondary Metabolites Production"** *organized by Department of Microbiology, School of Arts and Science, PRIST Deemed to be University, Vallam, Thanjavur, Tamilnadu on 07.10.2022*

A. Xavier Fernandes 10/10/2022.
Dr. A. Xavier Fernandes
HOD

10/10/22
Dr. L. Chinnappa
Dean

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Certificate of Appreciation

This is to certify that Dr. N. Sisubalan, Assistant Professor *from* Department of Botany, Bishop Heber College (Autonomous), Trichy *has acted as a resource person in one day seminar on* "Biofuels as Saviour of Earth" *organized by Department of Microbiology, School of Arts and Science, PRIST Deemed to be University, Vallam, Thanjavur, Tamilnadu on 07.10.2022*

10/10/2022

Dr. A. Xavier Fernandes
HOD

10/10/22

Dr. L. Chinnappa
Dean

SCHOOLOF ARTS AND SCIENCE

DEPARTMENT OF MICROBIOLOGY

ONE DAY SEMINAR ON SECONDARY METABOLITES PRODUCTION & BIOFUELS AS SAVIOUR OF EARTH

DATE : 07-10-2022 TIME : 11.30AM VENUE : RDC SEMINAR HALL

S.NO	NAME	DESIGNATION	SIGNATURE
1.	DR. L. CHINNAPPA	Dean Arts and Sci	
2.	Dr. A. XAVIER FERNANDO	AP/Microbiology	
3.	T. JAYASREE	AP/ BIOTECH	
4.	Dr. N. Mahalakshmi	AP/Micro	
5.	K. PRIYADHARSHINI	AP/CS	
6.	Dr. P. Senbagalakshmi	AP/Botany	
7.	Dr. T. Veeramani	AP/Biotech	
8.	Dr. J. Elamathi	AP/Biotech	
9.	Dr. N. SIVABALAN	AP/Botany	
10.	Dr. R. SATHYA	AP/Microbiology	
11.	Dr. P. Thiruselvi	AP/Micro	
12.	V. RAJAN	PD	
13.	Dr. Bathish kumar.	AP/BC	
14.	Dr. A. Ambiga	AP/BC	
15.	Prof. Vishvalingam	AP/BC	
16.	R. Rasakumar.	AP/EN	
17.	S. Priya	AP/Maths	

18.	K Sathya	B.Sc (III year) Microbiology	K.sathya
19.	F Rajeswari	B.Sc (III year) microbiology	F Rajeswari
20.	R chandralekha	III BSc microbiology	[illegible]
21.	Afisha Ramzeya A	III BSc Microbiology	Afisha Ramzeya A
22.	C. Sneha	III BSc Microbiology	[illegible]
23.	A. Amrutha	III Bsc MICROBIOLOGY	Amrutha
24.	K. Bhagathaswari	III BSc Microbiology	K.Bhagatha
25.	T. Nalini	III BSC Microbiology	T Nalini
26.	G. Raghul.	III. BSC microbiology	G. Raghul.
27.	S. AKASH	III BSC microbiology	S.AKASH
28.	P. Soorya	III. B.Sc Microbio	P. Soorya
29.	P. Saminathan	III. B.Sc microbiology	P das
30.	K. Sreepriya	III. BSc Microbiology	K.[illegible]
31.	S. Mahalakshmi	III. BSc Microbiology	mahalak.
32.	S.mohamed rashid	II Bsc microbiology	[illegible]
33.	P. Nandhana	II BSc-BIOTECH	[illegible]
34.	M. Gunasri	II BSC-BioTech	M. [illegible]
35.	S Srinithi	II. BSc BioTech	S. Srinithi
36.	S. Thigarajan	III BSC-micro	[illegible]
37.	A. Ratheesh	I-PG-micro	Rathish
38.	S. siva karthick Raja	I-PG-micro	Siva

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39.			
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Preparation and properties of Copper Oxide Nanoparticles through the aqueous precipitation method

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Abstract

The Copper nanoparticles are mainly utilized as an antimicrobial agent. They are used in hospitals due to their antimicrobial ability to kill more than 99.9% of Gram-positive and negative bacteria within 2 hours of exposure, if a suitable dose is applied. In this investigation, CuO NPs were prepared through the co-precipitation method. CuO NPs were characterized by X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM) and Photoluminescence studies. The different bond frequencies associated with the samples were assigned from their Fourier Transform Infra-Red (FTIR) spectra. The optical studies were explained by their UV-VIS and Photoluminescence spectra.

Keywords: CuO NPs, antimicrobial agent, XRD, FESEM, FTIR, UV-VIS, Photoluminescence spectra.

1. Introduction

The field of nanomaterials includes subfields that develop or study materials with unique properties that result from nanoscale dimensions. Surface science and colloidal science have created many materials useful for nanotechnology[1], such as carbon nanotubes and other fullerenes, various nanoparticles and nanorods. Nanoscale materials can also be used in large numbers of applications. Most of the current commercial applications of nanotechnology are in this flavor [2]. Advances have been made in using these materials for medical applications. See Nanomedicine. Nanoscale materials are sometimes used in solar cells[3, 7], which is competing with the cost of traditional silicon solar cells. Development of applications containing semiconductor Display technology, lighting, solar cells, biological imaging like nanoparticles used in next-generation products[5]. Copper oxide particles have been found to have mainly utilized the

antimicrobial agent as well as superior UV blocking properties compared to their bulk alternatives[6, 8]. These nanoparticles are hard and give them their properties.

2. Experimental and Characterization Methods

2.1 Synthesis

Copper oxide nanoparticles can be synthesized using the aqueous precipitation method. In this method, copper acetate is used as a precursor and sodium hydroxide as a stabilizing agent. Single phase monoclinic structure of the copper oxide nanoparticles is revealed using X-ray diffraction. The rectangular morphology of the copper oxide nanoparticles is revealed using the scanning electron microscopy. CuO nanostructures were synthesized by precipitation method using copper chloride ($CuCl_2$) and copper nitrate ($Cu(NO_3)_2.3H_2O$). First, each precursor was dissolved in 100 ml deionized water to form 0.1 M concentration. NaOH solution (0.1 M) was slowly dropped under vigorous stirring until pH reached to 14. Black precipitates were obtained and repeatedly washed by deionized water and absolute ethanol for several times till pH reached 7. Subsequently, the washed precipitates were dried at 80 °C for 16 h. Finally, the precursors were calcined at 500 °C for 4 h. investigated by X-Ray Diffractrometry (XRD). The morphology was monitored by scanning electron microscope (SEM). Chemical properties were investigated by Fourier transform infrared spectroscopy.

Chemical Data	
Chemical symbol	CuO
CAS No.	1317-38-0
Group	Copper 11 Oxygen 16
Electronic configuration	Copper [Ar] $3d^{10}$ $4s^1$ Oxygen [He] $2s^2$ $2p^4$

Chemical Composition	
Element	**Content (%)**
Copper	79.87
Oxygen	20.10

2.2 Physical Properties

The physical properties of copper oxide nanoparticles are given in the following table.

Properties	Metric	Imperial
Density	6.31 g/cm^3	0.227 lb/in^3
Molar mass	79.55 g/mol	

2.3 Characterization Techniques

The CuO NPs were characterized by X-ray diffractometer (model: X'PERT PRO PANalytical). The diffraction patterns were recorded in the range of 20^o-80^o for the CuO NPs sample where the monochromatic wavelength of 1.54 Å was used. The sample was analyzed by Field Emission Scanning Electron Microscopy (Carl Zeiss Ultra 55 FESEM) with EDAX (model: Inca). The FT-IR spectra were recorded in the range of 400-4000 cm^{-1} by using Perkin-Elmer

spectrometer. The absorption spectrum of CuO NPs was studied in the range between 190 and 1100 nm by Lambda 36spectro photometer. Photoluminescence spectra were taken using spectrometer JASCO Spectroflurometer FP-8200.

3. Results and Discussion

3.1 X-ray diffraction Studies

The X-ray diffraction patterns of the prepared samples are shown in Fig. 1 The XRD peaks are located at angles (2θ) of 31.849, 34.508 and 36.334 corresponding to (100), (002) and (101) planes of the CuO NPs. Similarly, other peaks found at angles (2θ) of 47.614, 56.668, 62.932, 66.45, 68.023, 69.106, 72.61 and 77 are corresponding to (102), (110), (103), (200), (112), (201), (004) and (202) planes of CuO NPs. The standard diffraction peaks show the hexagonal wurtzite structure of CuO NPs with space group $P6_3mc$. It is also confirmed by the JCPDS data (Card No: 36-1451).

This is the most stable phase of CuO NPs. The lattice constants ‘a’ and ‘c’ of the *wurtzite structure* of CuO*can be calculated* by using the relation [1],

$$\frac{1}{d^2} = \frac{4}{3}\left(\frac{h^2 + hk + k^2}{a^2}\right) + \frac{l^2}{c^2}$$

with the first order approximation (n = 1) for the (100) plane. The lattice constant ‘a’ is obtained through the relation a =$\frac{\lambda}{\sqrt{3}sin\theta}$ and lattice constant ‘c’ is derived for the plane (002) by the relation c =$\frac{\lambda}{sin\theta}$. The calculated values of ‘a’ and ‘c’ are 3.2418 Å & 5.1941 Å for CuO NPs.

The average crystalline size of the samples is calculated by Debye Scherrer’s relation

$$\text{Average crystalline size } D = \frac{k\lambda}{\beta_{Dcos\theta}}$$

Where, λ - the wavelength of the radiation (1.54056 Å for CuKα radiation), k - a constant which is equal to 0.94, β - the peak width at half-maximum intensity, θ - the peak position. The average crystalline size is 33nm for CuO NPs.

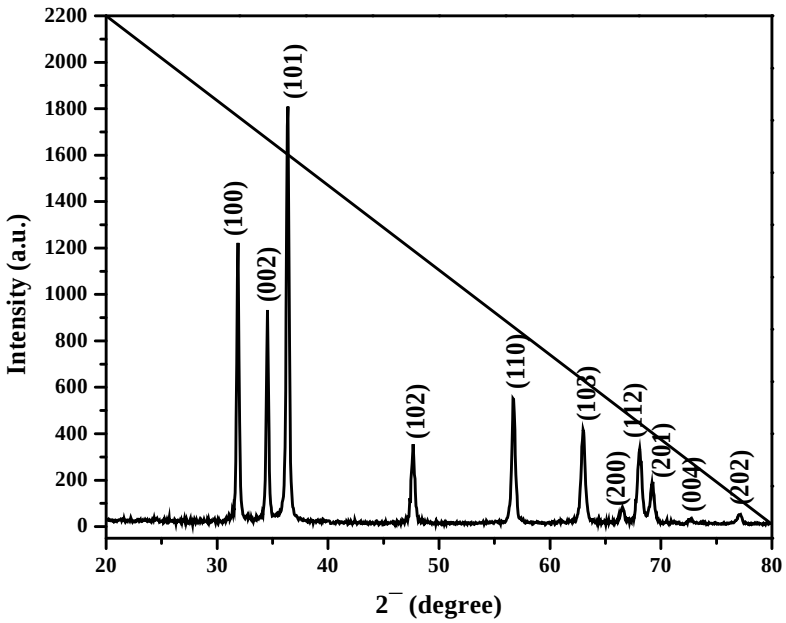

Fig.-1 X-Ray Diffraction Pattern of CuO NPs

3.2 Field Emission Scanning Electron Microscopic Studies

The FESEM is one of the promising techniques for the topography study of the sample and it gives important information regarding the growth mechanism, shape and size of the nanoparticles. The surface morphology of the CuO NPs is shown in Fig. 2. The entire FESEM image clearly shows the average size of the NPs in the order of nanometer size. The CuO NPs are tree like structure and top of tree uniform even grain boundaries formed. The uniform grain boundaries size 98 nm are found for the CuO NPs.

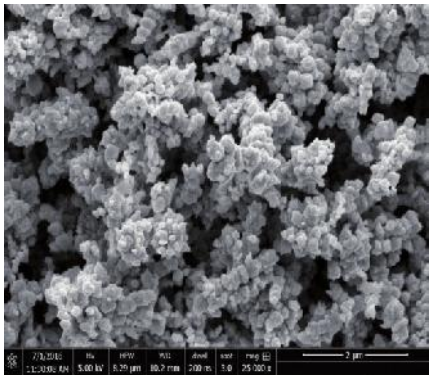

Fig.-**2FESEM Image of CuO NPs**

3.3 Fourier Transform Infra-Red (FT-IR) spectroscopicanalysis

FTIR analysis of CuO nanoparticles The FTIR spectrum (Figure.3) shows bands at around 601,508 and 487 cm-1 ,which can be assigned to the vibrations of Cu(II)-O bonds. There is sharp peak observed at 601 cm^{-1} in the spectrum CuO nanoparticles which is the characteristics of Cu-O bond formation. The broad absorption peak at around 3430cm^{-1} is caused by the adsorbed water molecules since the nano crystalline materials exhibit a high surface to volume ratio and thus absorb moisture.

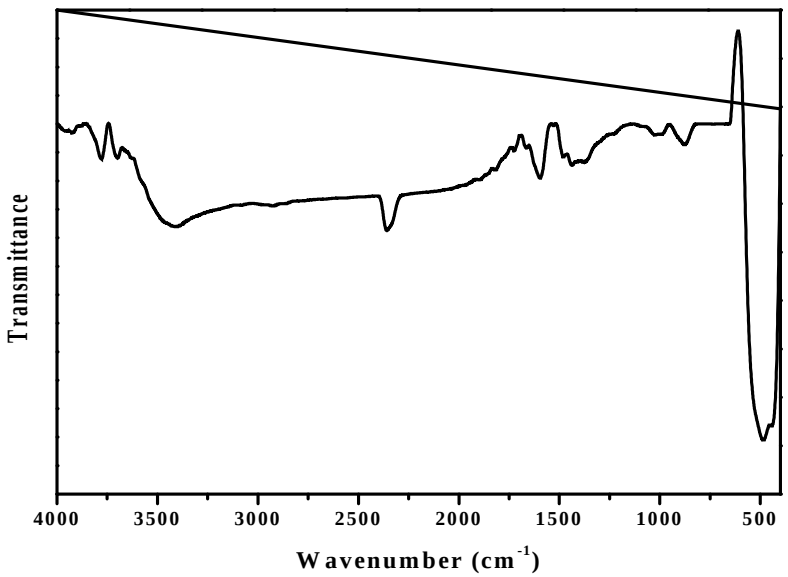

Fig. **3 FTIR spectra of the CuO NPs**

3.4 UV-visible absorption spectroscopy studies

Figure-4 shows the UV-visible absorption spectrum CuONPs. The CuO samples absorption spectrum sharp peaks at 372 nm were observed, which believe to arise from the near band edge free excitons. The CuO NPs are expected to show a small red-shift in comparison to bulk CuO. The band gap energies E_g, of CuO NPs were found 3.3 eV. Showed the small 'red shift' of 0.07 eV from standard bulk band gap at room temperature (E_g = 3.37 eV). Where ZnO NPs result in decrease to deviating from the Burstein-Moss shift [3, 4] the estimated band gap values are close to the bulk CuO, this gives conclusion that there is no indication of quantum size effect [5].

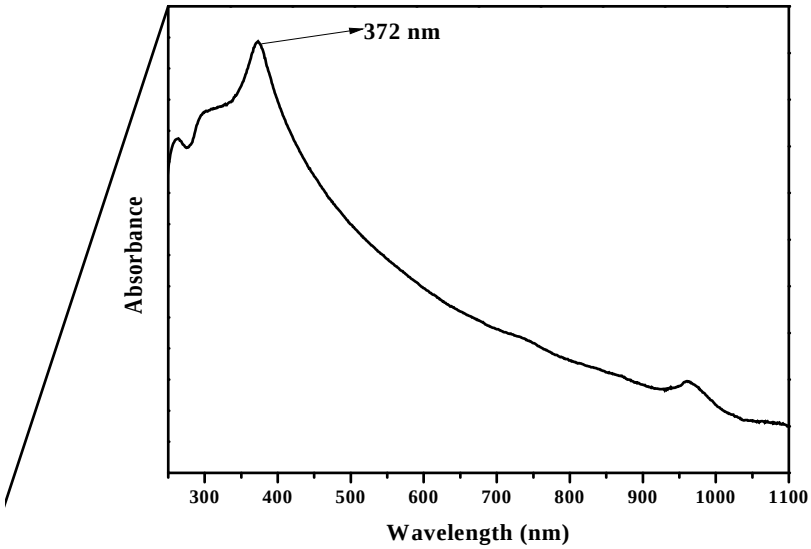

Fig.**-4 UV-visible spectra of CuO NPs**

3.5 Photoluminescence studies

The photoluminescence spectrum of the CuONPs is shown in Fig.4. The photoluminescence spectra of CuO NPs samples recorded with the excited wavelength of 325 nm. The emission spectra of the CuO NPs sample having six peaks at 395nm, 426nm, 440nm, 469nm, 483nm and 494nm. These bands are Near Band Edge emission, Violet emission, three blue emission and blue-green emission respectively. The NBE emissions is located at UV region 395nm for pure CuO NPs, this NBE emission is attributed to the radiative recombination between the electrons in the conduction band and the holes in the valence band. The green emission centered at 426 nm, and is ascribed to an electron transition from a shallow donor level of the natural copper interstitials to the top level of the valence band [5]. The three blue emission bands at 440 nm, 469 nm and 483 nm are attributed to singly ionized copper vacancies [6]. There is blue-green emission band at 494 nm due to a surface defects in the CuO NPs corresponding to the transition between oxygen vacancy and oxygen interstitial defect.

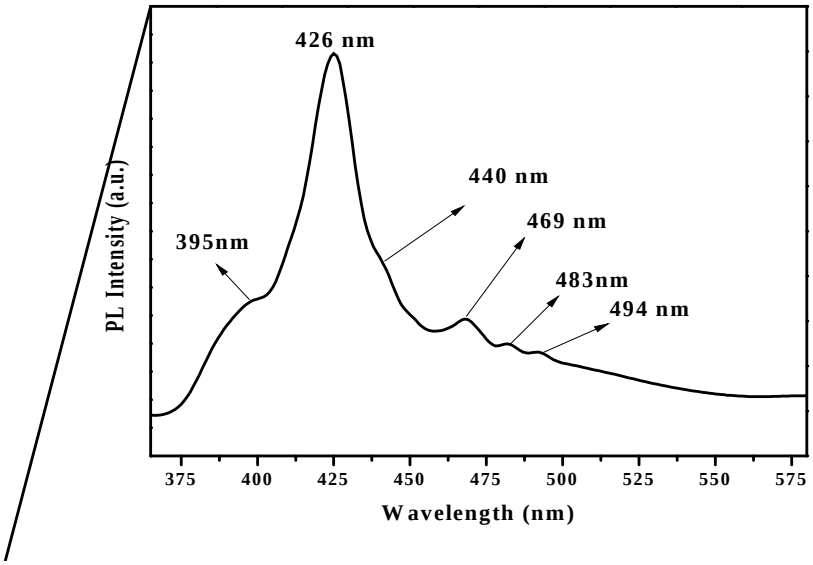

Fig. **5 -Photoluminescence emission spectra CuO NPs**

4. Conclusions

The CuONPs were prepared through the co-precipitation method. The X-ray diffraction study confirmed that the prepared particles were in a hexagonal wurtzite structure. The values of lattice parameters'a' and 'c' were found to be 3.2418 Å & 5.1941 Å respectively for CuO NPs. From the FE-SEM images, the CuO was a tree-like structure and at the top of the tree, even uniform grain boundaries formed. The uniform grain boundaries of 98 nm were found for the CuO NPs. From the FE-SEM analysis, the chemical compositions were estimated. Using the recorded FT-IR spectra, the various vibrational frequencies were assigned to the CuO NPs. From UV-Vis spectra, the CuO sample absorption spectrum sharply peaks at 372 nm. The photoluminescence studies showed that the CuO sample the band emission, which is due to copper vacancies, oxygen vacancies and surface defects.

Conflicts of interest

The authors declare no conflict of interest.

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