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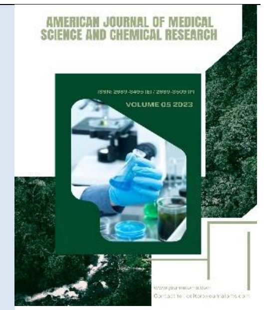

Synthesis of ZnO and glucose capped ZnO for fingermark enhancement.

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ABSTRACT

Synthesis of ZnO nanoparticles are done by using an innovative technique of chemical synthesis (co-precipitate technique). In this technique ZnO-NPs and Capped ZnO-NPs with glucose are produced by adding NaOH solution drop by drop on continuous magnetic stirring. by dissolving a precise quantity of zinc nitrate hexahydrate ($Zn(NO_3)_2 \cdot 6H_2O$) in distilled water to create a transparent solution. Subsequently, transfer the nitrate solution into a reaction vessel. While continuously stirring with a magnetic stirrer, gradually add NaOH solution drop by drop. This process should result in the formation of a white precipitate of ZnO, with continuous stirring ensuring thorough precipitation. To regulate particle size and enhance stability, introduce glucose into the reaction mixture as a capping agent, utilizing a magnetic stirrer to facilitate proper capping and stabilization of ZnO-NPs. Separate the ZnO-NPs from the solution by centrifuging the reaction mixture, followed by the collection of the precipitates. Subsequently, wash the obtained ZnO-NPs with distilled water to eliminate impurities. Dry the washed ZnO-NPs in an oven at a specified temperature to eliminate any residual impurities. Characterization of these particles were done by using confirmatory techniques like UV-Visible Spectroscopy, Photoluminescence Spectroscopy, Particle size analyzer, Zeta potential, Fourier transform Infrared radiations spectroscopy (FTIR Spectroscopy) and scanned electron microscopy (SEM). There are two different applications against which nanoparticles are added. 1st is Fingerprint enhancement and the 2nd is Antimicrobial activity. ZnO-NPs Provide very effective results against finger print analysis on both smooth and rough surfaces. Antimicrobial activity is studied under two different bacteria one is gram +ve S. auras and the other is gram –ve E. coli. S. auras show sensitivity with ZnO-NPs while E. coli didn't.

INTRODUCTION:

Zinc oxide is an inorganic compound with the formula ZnO. It usually appears as a white powder, nearly insoluble in water [1]. The powder is widely used as an additive into numerous materials and products including plastics, ceramics, glass, cement, rubber (e.g. car tyres), lubricants, paints, ointments, adhesives, sealants, pigments, foods (source of Zn nutrient), batteries, ferrites, fire retardants, etc [2,3,4]. ZnO is present in the Earth crust as a mineral zincite; however, most ZnO used commercially is produced synthetically. In materials science, ZnO is often called a II-VI semiconductor because zinc and oxygen belong to the 2nd and 6th groups of the periodic table, respectively [5,6]. This semiconductor has several favorable properties: good transparency, high electron mobility, wide bandgap, strong room-temperature luminescence, etc [7,8]. Those properties are already used in emerging applications for transparent electrodes in liquid crystal displays and in energy-saving or heat-protecting windows, and electronic applications of ZnO as thin-film transistor and light-emitting diode are forthcoming as of 2009 [9,10].

Small particles, on the order of 1–100 nanometers in size, are referred to as nanoparticles. The Greek word for "dwarf" (nano) is the root of the modern definition of a billions of a material sizes. When it comes to working with nanoparticles, Ursula Scheffel and his group were pioneers. Specifically, nanotechnology is the study of extremely small particles called nanoparticles. The substance is studied on a molecular and subatomic scale. Due to their minute size, nanoparticles cannot be seen with the human eye. Due to their small size, they are finding applications in a variety of fields, including physics, molecular biology, chemistry (organic and inorganic), material science, and medicine. Nanotechnology, an interdisciplinary realm with profound implications spanning energy, medicine, healthcare, drug delivery, environment, genetics, food industry, automotive industry, electronics, robotics, textiles, and cosmetics, has garnered significant attention since its inception. Coined from 'nano,' representing minuteness, and 'technology,' indicating a collection of skills and processes at the nanoscale, this field captivates scientists due to its pivotal advantages, size efficiency, versatility, and a spectrum of unique physical and chemical properties [11]. The exceptional optical characteristics of nanomaterials amplify their sensitivity, utilizing luminescent attributes to alleviate background interference. Nanoparticles have emerged as indispensable components in diverse domains, including medicine, genetics [12], the food industry, biomedical applications, robotics, drug delivery, fingermark sensors, wound healing, and the treatment of diabetes mellitus [14]. Various types of nanoparticles have been synthesized, each tailored for specific applications in distinct fields. The role of nanotechnology is new in the field of forensic science one such area is in the development of latent fingerprint.

In recent times, the utilization of nanoparticles in forensic science to enhance latent fingermark development has gained significant importance. Trace evidence, particularly the precise examination of fingermarks, holds crucial significance in 20th-century criminal investigations worldwide. Fingermarks, often encountered at crime scenes, play a vital role in personal identification, showcasing impressions of ridges and furrows from the palmer surface of fingers upon contact with another surface. Distinguishingly, the palmer surface of hands and the hoofer surface of feet exhibit unique characteristics designed for grip. These impressions emerge as the middle skin layer

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outgrows the inner dermis and epidermis folds [15, 16]. Globally, approximately 60–70% of the population possesses a loop pattern, 30–40% exhibit a whorl pattern, and only 5% display an arch pattern, making it the least encountered. Fingermarks endure throughout an individual's lifetime, remaining unchanged and serving as a robust tool for unique The recovery and enhancement of fingermarks from crime scenes are pivotal for individual identification, linking the offender to the location. Often imperceptible, these fingermarks necessitate specialized techniques for their development [17, 18]. Powder dusting stands out as the most widely utilized visualization method, encompassing regular, metallic, magnetic, and luminescent sources [19]. Regular powder, composed of resinous polymers (starch, rosin, silica gel) and colorants (dolomite, aluminum flake), present challenges in latent fingermark identification. Magnetic powder, incorporating non-magnetic colorants (carbon black powder, aluminum flake), offers an alternative solution. However, the health risks associated with metallic powder, containing toxic elements such as gold, lead, and silver [20], warrant caution for users. The non-uniformity and non-dispersed nature of commercial powders, with a size range of ~0.2–2 μm, adversely impact detection sensitivity by covering sweat pores and interfering with detailed fingermark features. personal identification.

MATERIALS AND METHODS

2.1 Chemical synthesis of ZnO-NPs

There are the following steps to which we can follow and get chemical synthesis of the most precious nanoparticles of ZnO.

1. Preparation of solution
2. Attaining the pH 10.0
3. Centrifugation of the solution to separate the ppt.
4. Dry in oven
5. Perform test for characterization
6.

2.1.1 Preparation of solutions

First of all we should have to prepare the solutions of all the chemical substances according to the molarity which we have required by using the following formula:

$$Molarity = \frac{Mass}{MM\ X\ volume\ of\ the\ sol.} X\ 1000$$

Method to prepare 20ml solutions according to its molarity is given below in tabular form:

Prepare 20ml solution of the solute in distilled water

	$Zn(CH_3COO)_2.2H_2O$	**NaOH**	**C6H12O6**
Molar Mass	219.49 $gmol^{-1}$	40 $gmol^{-1}$	180 $gmol^{-1}$
Volume of solvent	20 ml	20 ml	20 ml

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Required mass	2.195 g	0.8 g	0.72 g
Moles	0.5 mol	1.0 mol	0.2 mol

2.1.2 Attaining the pH 10

We can prepare the solution of Zinacetate dihydrate, Sodium hydroxide and Glucose of 0.5M, 1.0M and 0.2M by adding 2.195g, 0.8g and 0.2g into 20ml distilled water respectively. After preparing the solutions, add both solutions 0.5M Zinacetate dihydrate and 0.2M Glucose and retain it for 2 hours in continuous stirrer with the help of a magnetic stirrer. In this way both glucose and zinacetate dihydrate are completely mixed. At that time the pH of the solution is 5.0. Now we have to add solution of NaOH in such a way that the pH is altered into 10.0. The solution of NaOH is added with the help of drop regulator which add NaOH into the stirring solution droop after drop. It takes 2 days very slow adding of NaOH solution and attains the required pH.

2.1.3 Collection of ZnO-Nanoparticles

Take the solution into test tubes and centrifuge it 3000 revmin^{-1}. In these way we get white color cleared precipitate in the test tube. Collect them dry them now they are ready for the characteristic evaluation.

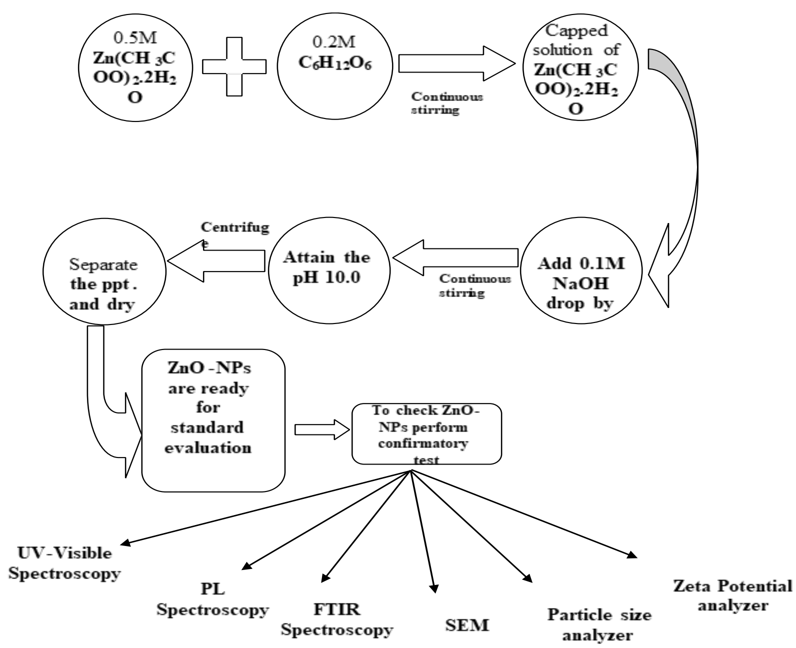

Figure 7 Flow sheet diagram of methodology

2.2 Characterization:

In this study, a detailed exploration was conducted on the synthesis of ZnO and glucose-capped ZnO for the purpose of fingermark enhancement. Various characterization techniques were employed to unravel the properties of the synthesized materials. The utilization of photoluminescence spectroscopy not only provided insights into electronic structure but also allowed researchers to gauge the materials potential in various optical applications. UV-Visible spectroscopy not only delved into absorption and transmission properties but also offered essential

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data for understanding how these materials interact with light, crucial for their performance in forensic applications. Furthermore, the employment of FTIR spectroscopy went beyond identifying functional groups; it facilitated a deeper understanding of the molecular vibrations, aiding in predicting the chemical behavior of the synthesized materials. Zeta potential analysis, in assessing surface charge, not only contributed to colloidal stability comprehension but also hinted at potential interactions with biological surfaces, an important consideration for forensic applications. The comprehensive nature of X-ray diffraction, elucidating crystal structure and phase purity, reinforced the materials' integrity, essential for their reliability in practical applications.

In summary, this multi-faceted approach, encompassing various spectroscopic and analytical techniques, not only enriched the understanding of the synthesized materials' characteristics but also laid the groundwork for their potential use in the intricate realm of fingermark enhancement, where a nuanced comprehension of both structural and surface properties is paramount.

RESULTS AND DISCUSSION

3.1 UV-Visible Spectroscopy:

UV-Visible spectroscopy is a technique which shows special character of a particle in our given condition, Literature confirmed it that 278nm is Lambda max which is a peaks specifically for ZnO-NPs. In the given below diagram ZnO-NPs solution is studied under the UV-Visible spectroscopy in Nano-Lab of Chemistry Department GCU, Lahore.

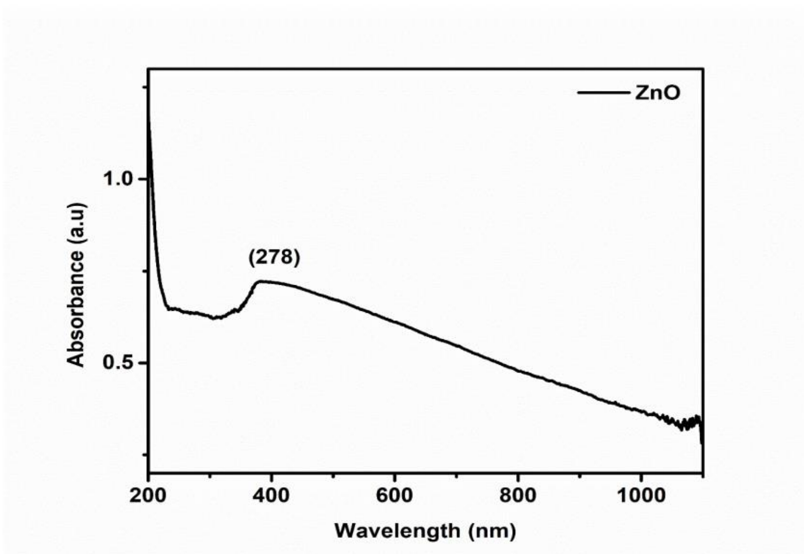

Figure 3.1 UV-Visible Spectroscopy

3.2 Photoluminescence Spectroscopy:

In the given below diagram two graphs shown in which one graph show transition of 235 to 253nm and the other on a specific wavelength like 235 nm it shows the transition of 420nm to 470nm. This transition shows the pi-shift which is actually a characteristic of ZnO-NPs.

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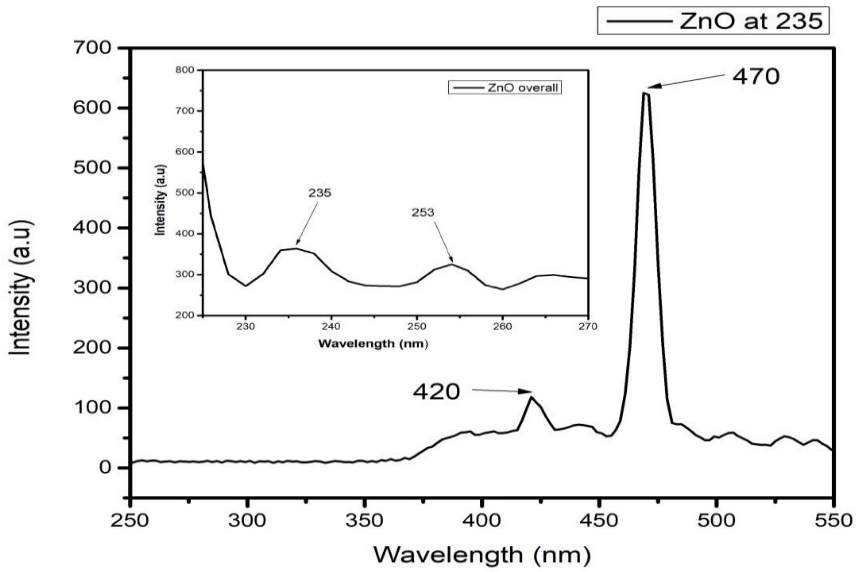

Figure 3.2 Photoluminescence Spectroscopy

3.3 Zeta Potential analyzer:

Zeta potential is actually the measure of force between the interaction of metal or Metal Oxide substance and the capped molecule around it. A solution is prepared ZnO and capped ZnO-NPs with glucose. Actually zeta potential is the measure of force between glucose and ZnO-NPs substance. In Zeta analyzer potency is measured in -26.5 which is considered a good value between glucose and ZnO-NPs. Some other information's are also obtained from Zeta potential that are given below.

Properties	Values
Mean Zeta Potential	-0.49mV
Standard deviation	0.51
Conductivity	0.15mS/cm
Distribution peak	1.51mV
Auto run criteria	100

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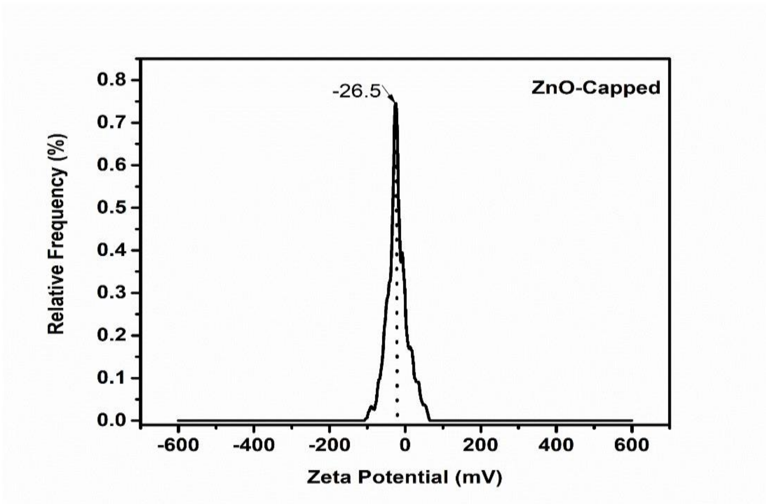

Figure 3.3 Zeta Potential analyzer

3.4 Particle Size analyzer:

Particle size analyzer is a special technique in which 0.5mg solution of salt is prepared in its own solvent and vigorously mixes it until a homogenous mixture is not formed then it is analyzed. The particle size is 81.49nm which is hydrodynamic size this is confirmed its size which is nanometer. Hence, we can conclude that these are nano-particles.

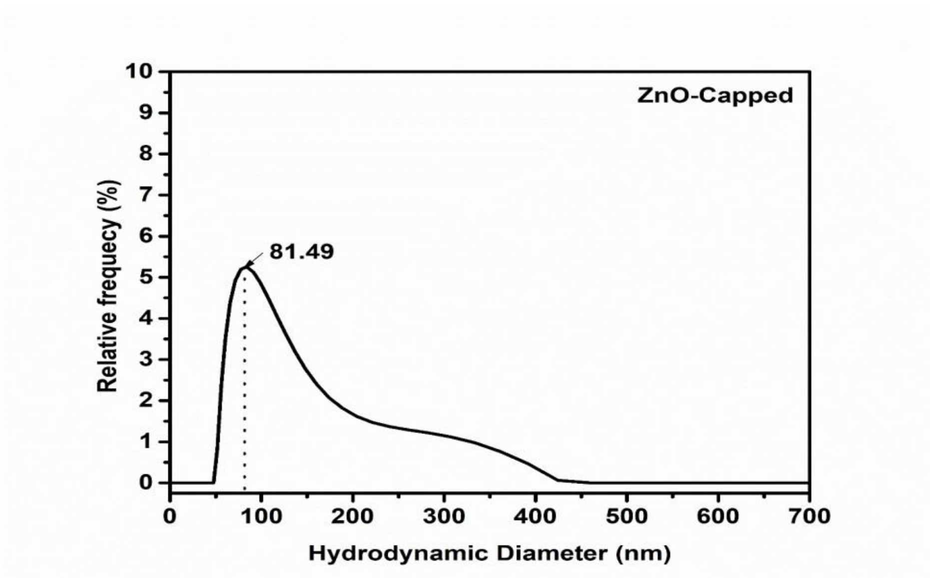

Figure 3.4 Particle Size analyzer

3.5 Fourier Transforms Infrared Radiations Spectroscopy:

FTIR is special technique give us knowledge about the presence of different functional group in Zn and ZnO-NPs capped with glucose. The range of FTIR-Spectrum lies between 4000-400cm. The stretching vibration of Zn and ZnO-NPs capped with glucose produced by co-precipitate mechanism of chemical synthesis are at 3367, 1560, 1401, 1345, 1025, 670,559. The vibrational peak observed at 3367 cm^{-1} is describing the presence of 0-H

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stretching and it is confirmed through the literature. The vibrational peak observed at 1560 cm^{-1} and 1401 cm^{-1} is describing the presence of C=O stretching. The vibrational peak observed at 1345 cm^{-1} is describing the presence of $-CH_2$ stretching for alkane. The vibrational peak observed at 1025 cm^{-1} is describing the presence of C-O stretching for amino acids. The vibrational peak observed at 670 cm^{-1} is describing the presence of Zn-0H secondary vibration and it is confirmed through the literature. The vibrational peak observed at 559 cm^{-1} is describing the presence of ZnO nanoparticles secondary vibration.

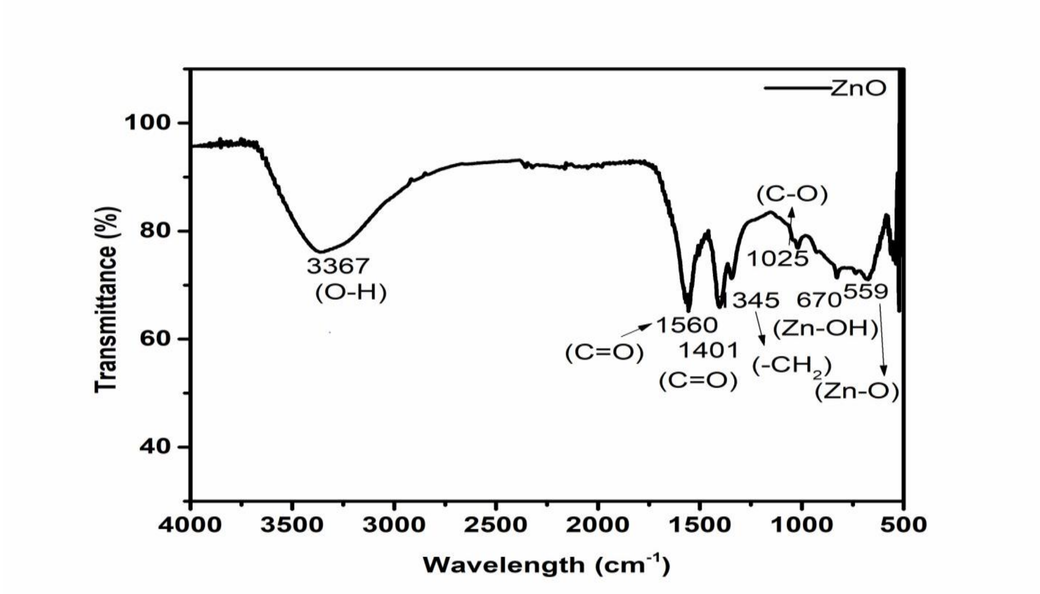
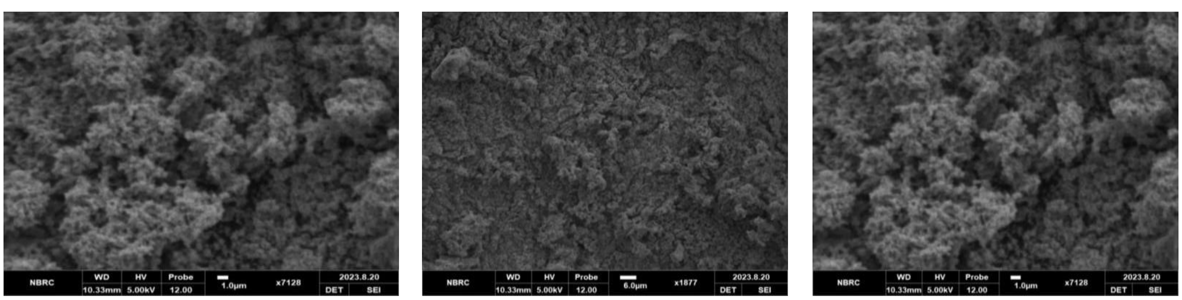


Figure 3.5 Fourier transforms Infrared Radiations Spectroscopy

3.6 Scanned Electron Microscopy:

SEM is one of the best confirmatory techniques used to analyze the structure and shape of different particles. It gives us a pictorial diagram of the particles. In the results it is clearly see the amorphous shape of the particles from literature it confirms ZnO-NPs. There are three different views seen at three different resolutions.



(a) **(b)** **(c)**

Figure 3.6 Scanned Electron Microscopy

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3.7 Application in Forensics:

3.7.1 Fingerprint Analysis

When ZnO-NPs are applied over rough and smooth surface containing marks of finger print, these particles are enhanced the fingerprint in an enormous way. Because these are white colored Nano-particles hence I considered dark surfaces for good results ridges and rigs are properly seen bifurcation of the lines can be see easily. It is called third degree of analysis.

Figure 3.7 Finger mark enhancement on smooth and rough surface

(a) Middle and ring finger on smooth surface
(b) Thumb at high resolution on smooth surface
(c) Thumb at low resolution on smooth surface
(d) Thumb impressions on rough surface

3.7.2 Antimicrobial activity:

Antimicrobial activity is studied against two different bacteria one is gram +ve Staphylococcus aurous and the other is gram –ve bacteria the most popular E. coli. Take an inoculum of both bacteria and spread over MH agar plate containing antibiotics disc of Meropenum for E. coli and Linezolid for Staphylococcus aurous on separate plates respectively. Incubations of approximately 24 hours reveal very remarkable results. E. coli didn't show zone of inhibition it means E. coli is not sensitive for these particular Nano-particles while Staph aurous show zone of inhibition it means bacteria are sensitive for this particles. It shows 1.3cm of zone of inhibition which is a remarkable value.

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Figure 16 Staph aurous grown at MH agar. Linezolid disk is use as a control. ZnO -NPs placed after 24 hours incubation bacteria show no growth and a good zone of inhibition is seen.

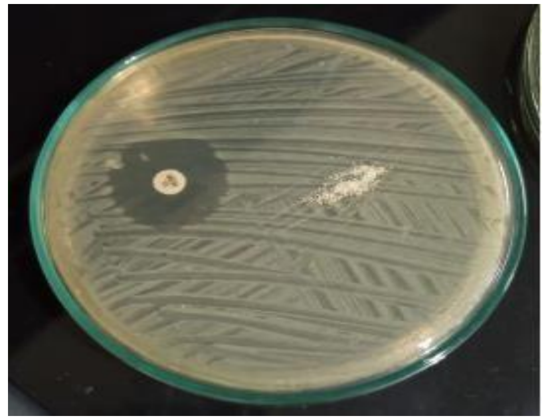

Figure 17 E. c oli grown at MH agar. Meropenum disk is use as a control. ZnO - NPs placed after 24 hours incubation bacteria shows growth and no zone of inhibition is seen.

CONCLUSION

Under the influence of the results and application, It is concluded that these particles are Nano-sized and have a very useful application toward Fingerprint analysis and antimicrobial activity. The entire confirmatory test like UV-Visible Spectroscopy, Photoluminescence Spectroscopy, Particle size analyzer, Zeta potential, Fourier transforms Infrared radiations spectroscopy (FTIR Spectroscopy) and scanned electron microscopy (SEM) confirms these particles and its nature. In UV-Visible Spectroscopy absorbance is seen at 278nm. The -ve value of zeta potential describe that the interactions of the surrounding glucose around ZnO is toward its center. Particle Size Analyzer gives a size of 81.49nm. FTIR give different vibrational peak like 3367, 1560, 14601, 1345, 1025, 670 and 559 in cm^{-1} for O-H, C=O, $-CH_2$, C-O, Zn-OH and Zn-O respectively. SEM give amorphous shape. Enhancement of finger print against the dark surfaces both rough and smooth shows good results of nanoparticles and considered to be a good application. In the same way results of antimicrobial activity strongly recommended that these particles are providing fruitful results.

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