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SYNTHESIS AND CHARACTERIZATION OF ZnO NANOPARTICLES FOR POTENTIAL APPLICATION IN LATENT FINGERPRINT DEVELOPMENT

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Abstract
The presentresearch work includes the synthesis and characterization of zinc oxide (ZnO) nanoparticles and their utilization for the development of latent fingerprint development. The synthesis of ZnO nanoparticles involves an economical precipitation process using zinc acetate dihydrate [$Zn(OOCCH_3)_2.2H_2O$] and ethylene glycol ($C_2H_6O_2$) as precursors.The structural examination of synthesized nanoparticles was done by employingField Emission ScanningElectron Microscopy (FE-SEM) and particle size analysis which showed that the nanoparticles formed were primarily hexagonal shaped and had an average size of up to 100 nm. The crystalline nature of the nanoparticleswas further verified by X-ray diffraction (XRD) study which confirms the hexagonal wurtzite structure of ZnO. These nanoparticles were then investigated as potential candidates for the development of latent fingerprints by testing them on various surfaces. From these studies, it has been observed that these nanoparticles helped in improving contrast and visibility, of the latent fingerprints, thereby helping in their effective revealing. The encouraging outcomes of the present work would be helpful asaprospective application of the synthesized ZnO nanoparticles in forensic research. Improvements in fingerprint detection methods could result from more optimization and analysis of their qualities, which would help law enforcement with criminal investigations.

Keywords: Criminal investigations, Latent fingerprint, FE-SEM, XRD, ZnO nanoparticles.

1. Introduction

Fingerprints are the imprints left behind on the surface due to the frictional ridges that are present on the tip of the fingers and thumb. It is the perfect means to identify the person’s identity as every individual has their own and unique fingerprints which don’t match with any other person’s fingerprint and also it is permanent and never get changes with time or age. It helps to identify the person’s real identity also if person is denying or not accepting his identity or changes his name, or change in the personal identity or appearance by the result of any disease, age or by personal intervention of the person like plastic surgery or by the means of accident [1].
There are three types of fingerprint evidence that can be found at a crime scene: latent/invisible prints, plastic prints, and visible prints, also known as patent prints. Among these types of fingerprints,latent prints need to be developed or enhanced in order for their visualization to be possible as they are not visible to the human eye [2].There are various new methods have been devised for latent fingerprint

detection however the powdering method is still the standard method for treating latent prints in fingerprint detection.These powders are generally classified into four classes: metallic, luminescent, thermoplastic, and regular[3]. The majority of the conventional methods involve chemical reactions or physical interaction between the developing agent and one or more than one components of the finger-mark residues, which consists of a varied mixture of water, triglycerides, fatty acids, sterols, inorganic salts, proteins and amino acids [4-6].
Nanotechnology is the field of science that deals with the study of materials in the nanometer scale [7]. This scientific area involves the manipulation of matter in the scale between 1-100 nm. In the recent years, the development of potential nanoparticles has revolutionizedalmost every field of research. Currently, nanotechnology has vast applications in different fields including electronics, drug development/analysis, and construction [8].

2. Experimental

2.1 Chemicals Used

Zinc acetate dihydrate [HIMEDIA, purity 98.0%] was used after drying it in the dry air oven at temperature between 30-40ºC for 24 hours.Ethylene glycol [FISHER SCIENTIFIC, purity 99.5%] and acetone [HIMEDIA, purity 99%] were used as obtained.

2.2 Methods

2.2.1 Synthesis of ZnO nanoparticles

Zinc oxide nanoparticles were prepared by using a self-devised novel method. 50 ml of 0.2 M aqueous (using distilled water) zinc acetate dihydrate solution was prepared in a clean conical flask. To the above solution, 50 ml of ethylene glycol was gradually added under continuous stirring with a magnetic stirrer. The resultant solution was then sonicated for 2 hoursata temperature of 50ºC. The solution was then refluxed at 330°C (inside the flask) for 1 hour and 30 minutes. To eliminate any remaining moisture from the acetone, the solution was sonicated in acetone for two intervals of 20 minutes each. The final solution was then placed in a hot air oven set at 80°C for 24 hours, allowing both water and acetone to evaporate, resulting in the production of dry ZnO nanoparticles powder. The prepared nanoparticles were beige in colour as can be seen from the **Figure1**.

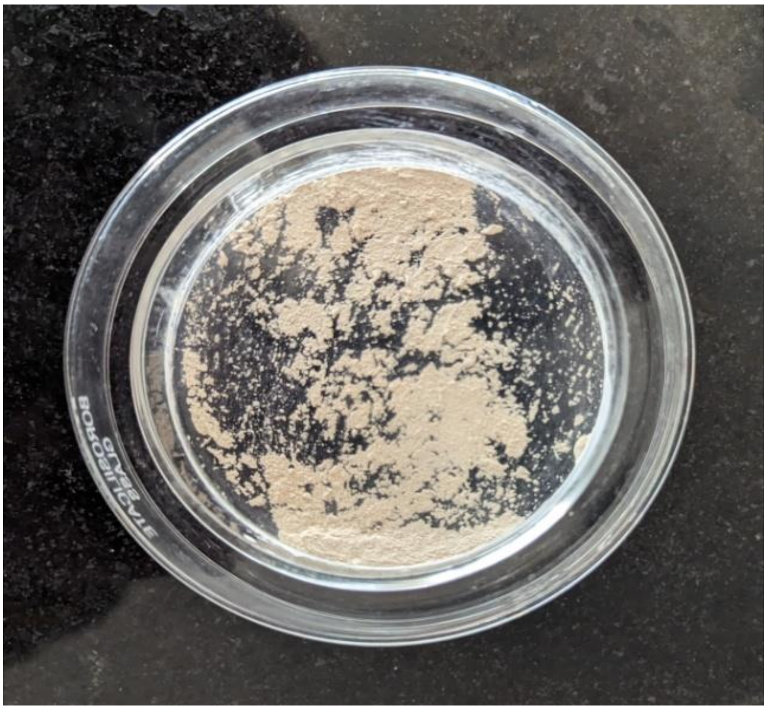

Figure 1: The image of the synthesized ZnO nanoparticles

3.Characterization Techniques

The synthesized ZnO nanoparticles were characterized using the techniques like X-ray diffraction (XRD) [9-16], Fourier Transform Infra-Red Spectroscopy (FTIR) [16-27] and Field Emission Scanning Electron Microscopy (FE-SEM) [28-34] to get evidence for the successful synthesis of the nanoparticles. FTIR spectrum was observed by mixing the powdered sample (1- 3%) with KBr (97-99%) to form pallet and analyzed the % transmittance in Bruker spectrum 65 FTIR system. FE-SEM (JSM 761) was observed at magnification of 100kX.

X-ray diffraction of ZnO nanoparticles was done from 00-80 degree by Pananaytical Xpert Pro with X-ray wavelength 0.1542nm.

4. Results and Discussion:

The prepared zinc oxide powdered nanoparticles were characterized for the presence of crystalline phases by FTIR. The FTIR spectrum of the synthesized nanoparticles exhibited characteristic peaks for ZnO. The peak at 1029.20cm^{-1}, 1336.91cm^{-1}, 2024.47cm^{-1}, 2162.81cm^{-1} and 3358.30cm^{-1} are the indicators of synthesis of nanorods of ZnO[35] (**Figure 2)**.

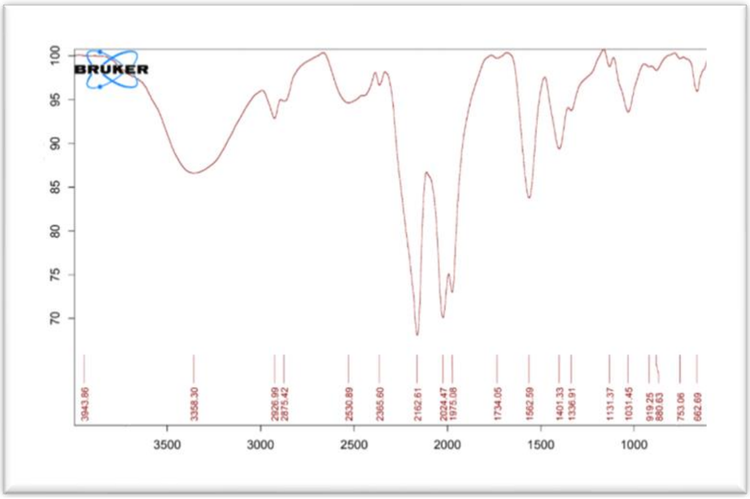

Figure 2: FTIR spectrum of the synthesized ZnO nanoparticles

The FESEM images of the synthesized ZnO indicate that attained particles were below 100 nm in size and crystalline in nature and formed nanorods (**Figure 3)**.

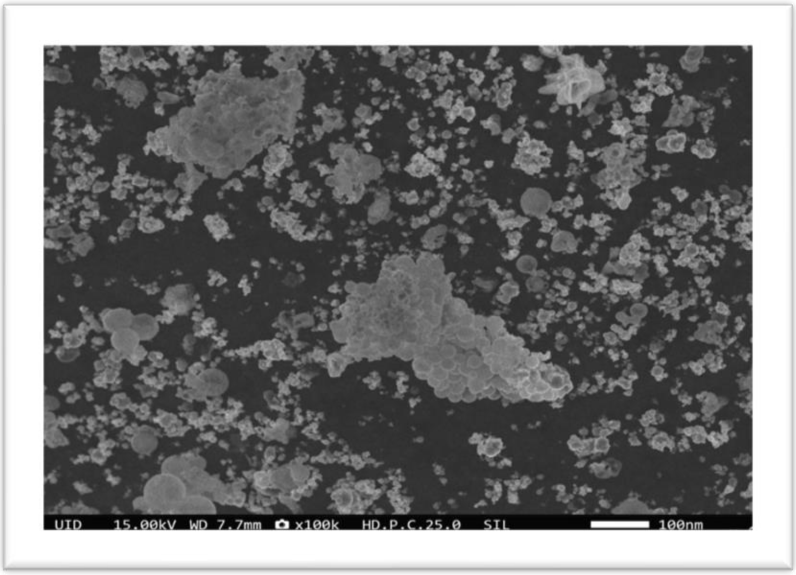

Figure 3: FESEM images of the synthesized ZnO nanoparticles

The XRD patterns of zinc oxide shows intense diffraction peaks of the ZnO were observed at 22.686°, 26.251°, 32.005°, 34.663°, 36.483°, 37.242°, 46.052°, 47.762°, 56.807°, 63.0679°, 66.578°, 68.1528°, 69.292°, 72.775° and 77.154° (**Figure 4)**. The crystallite size of ZnO was found to be 100 nm.

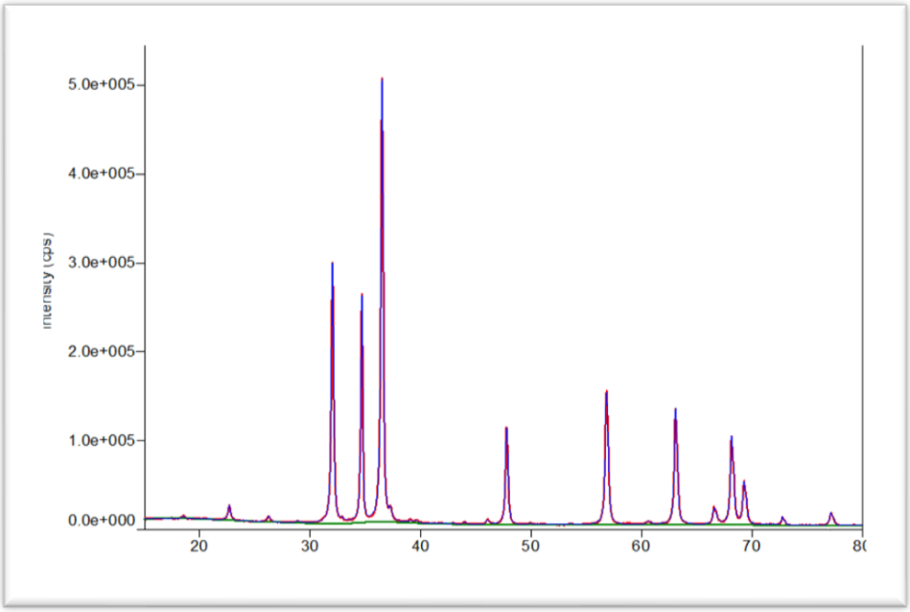

Figure 4: XRD of the synthesized ZnO nanoparticles

5. Development of Latent Fingerprints

The synthesized ZnO nanoparticles were employed for the development of latent fingerprints from five different non-porous surfaces namely glass, CD (polycarbonate plastic), steel, plastic, and wooden surface. The standard method [36] was followed for the generation and attainment of fingerprints. The latent fingerprints were generated by pressing the right thumb of the subject individual onto the surface. The hence-produced latent fingerprints were developed by powder dusting method [37]

employing synthesized ZnO nanoparticles and excess of the powder was removed by tapping. The ZnO nanoparticles being beige in colour helped develop very clear images of the latent fingerprints as depicted in **Figure 5**. However, on a closer inspection of the images, it was observed that the latent fingerprints developed from CD **(Figure 5.b)** presented a very distinct pattern as compared to that from polycarbonate plastic that lacked moisture content.

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

(d) (e)

Figure 5: Fingerprint developed on (a) glass, (b) CD (polycarbonate plastic) (c) steel, (d) plastic sheet and (e) wooden surface using ZnO nanoparticles.

6. Conclusion

A novel and economical approach was successfully developed for the synthesis of ZnO nanoparticles. The characterization investigations carried out pointed towards the successful synthesis of nanorods of ZnO of size below 100nm as confirmed by the results of FTIR studies, FESEM images and XRD data. The ZnO nanoparticles were further explored for their applications in forensic science and thus employed for development of latent fingerprints from three random surfaces chosen that is glass, CD (polycarbonate plastic), steel, plastic, and wooden surface. The results obtainedfor these studies were found to be very encouraging as they helped in revealing the clearer and easily distinguishable images of fingerprints. This study can further be extended for development of latent fingerprints from varied surfaces found in the criminal investigations.

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