Synthesis Of Zinc Oxide Nano Rods for Biosensor Applications

S. Panimozhi[1*], M. Jananni[1], M. Lekhasri[1], L. C. Kiruthika[1], P. Karkuzhali[1]
Department of Chemistry, Theivanai Ammal College for Women (A), Villupuram, Tamilnadu

***Corresponding author:**
Dr. S. Panimozhi1*
Department of Chemistry
Theivanai Ammal College for Women (TACW) Villupuram, India.
Email ID: panimozhi94@gmail.com

ABSTRACT
Without the need for computations, ZnO nanoparticles were made from zinc sulphate (dry) monoxide using the sol-gel technique (precipitation NaOH). Under various temperatures, a comparison of the chemical processes that convert zinc sulphate (dried) monoxide to ZnO was made. Fourier transform infrared spectroscopy (FTIR), scanning electron spectroscopy (SEM), and x-ray diffraction analysis (XRD) were used to characterise the precipitated chemical. These characteristics were displayed by the ZnO nanoparticles.

Keywords: ZnO nanoparticles, Sol-gel, FTIR, SEM,XRD

INTRODUCTION

A biosensor is a type of investigative tool that generates electrical signals in response to biological analyte detection. A biosensor typically consists of a transducer part and a sensing part. The component that detects the target in actual samples is the detector, and the transducer gathers data from the detector and sends a signal to the output system. A sort of investigative equipment that generates electrical signals in response to the detection of biological analytes is known as a biosensor [1]. It can also be described as an analytical tool that converts an electrical signal based on the concentration of the analyte being utilised from the reaction of a chemical biomatrix, such as antibodies, enzymes, etc. It can also be characterised as an analytical tool that transforms the reaction of a specific chemical biomatrix, such as antibodies, enzymes, etc., into an electrical signal, dependent on the concentration of the analyte being used [2]. A transducer part and a sensing portion are the standard components of a biosensor. The detector is the part that recognises the target in real samples, and the transducer collects data from the detector and transmits a signal to the output system.

Because of their abundance in nature, wide band gap n-type conductivity, and eco-friendliness, zinc oxide (ZnO) nanorods are a desirable and promising material. Due to these properties, this material is appealing for a variety of uses, including electrical devices, antibacterial coatings, optical coatings, photo catalysts, solar cells, and biofouling-resistant membranes. ZnO nanoparticles are unquestionably more affordable than TiO_2 and Al_2O_2 nanoparticles, costing only one-fourth as much. ZnO nanorod structures differ greatly from ZnO nanorod and nanowire structures in that they have many intriguing and distinctive characteristics, such as porous architectures and huge surface areas. Recent studies have shown that ZnO tubular structures work better and have higher sensitivity than ZnO nanorods and nanowires as sensors [3-6]. The application of ZnO nanorods as pH sensors, however, has not yet been reported. In this study, we showed a novel method for creating tunable zinc nanorods from zinc oxide nanorods. Zinc oxide nanorods modified Indium Tin Oxide (ITO) electrode, followed by chemical etching. For the purpose of identifying biological molecules at the nanoscale, customised ZnONTs/ITO electrodes were constructed.

Nanoparticles (NPs) have completely changed every major industrial sector, from medication delivery to the food and agricultural industries [7]. Emulsion solvent extraction, double emulsion and evaporation, salting out, emulsion diffusion, and solvent displacement/precipitation are a few of the chemical synthesis techniques for NPs. However, the production of NPs on an industrial scale has introduced a new type of pollution into the environment. By creating new, practical ways to get around the limitations of chemical processes, increase yield, and lower costs, it is extremely desirable to minimize the loads of chemical pollution on the environment [8].

Based on factors like mobility, sensitivity, and overall device performance, the biomaterials for this investigation were chosen. Conducting polymers and zinc oxide biomaterials, which have several advantages over other biomaterials, were used in this work. Excellent tunable electrical, magnetic, and optical properties are present in them. Due to its biocompatibility and relatively high electrical conductivity due to its conjugated electrons, conducting polymers, particularly polypyrrole, have interesting uses in the field of biosensors. It also has other appealing qualities including good room-temperature stability and simple polymerization conditions [9]. The fact that polypyrrole can be produced at lower potentials without affecting the material's other properties is another benefit over other biomaterials [10,11].

Nowadays, ZnO has been widely investigated for plant protection products, fertilizers, soil improvement, water purification, and many other [12–13]. Antimicrobially active packaging is a new generation of nano-food packaging based on metal nanocomposites which are made by incorporating ZnO into polymer films [15–18].

Sol-gel deposition techniques are less expensive and more suitable for vast areas than physical vapour deposition methods. They are also compatible with high deposition speeds and provide exceptional control over the morphologies of the nanostructures. There are three key phases in sol-gel techniques. The preparation of the sol from raw components comes first. Secondly, the sol must be deposited onto the substrate using a suitable deposition technique, and then the xerogel film must undergo a final heat treatment, produced ZnO nanorods using a sol made from equal parts hexamethylenetetramine (HMTA) and $Zn(NO3)_2 \cdot 6H_2O$. Crystallite ZnO nanorods with hexagonal wurtzite structures are produced on the SiO_2/Si substrate at a temperature of about 95 °C. By changing the concentration of the starting ingredients, the diameter of the nanorods can be altered. For the manufacture of the sol, Zn nitrate hexahydrate was dissolved in deionized water with urea. This solution was utilised to generate the nanorods and nanowires. After 24 hours of deposition and 48 hours of growth under the same growth conditions, nanowires and nanorods were produced. Precursors include Zn nitrates, chlorides, alkoxides, and Zn acetate dihydrate, among others. Due to their insolubility in alcohols, alkoxides are not favoured, while the use of acetate dihydrate results in volatile by-products and the anionic species in the final product are difficult to remove when employing inorganic salts like nitrates. The sol-gel procedure is briefly reviewed. [19].

EXPERIMENTAL METHOD&MATERIALS

MATERIALS

- Zinc sulphate dry monoxide
- Sodium hydroxide

METHOD

All of the reagents are analytical grade and don't need any additional purification before use. The precursor was made by adding 50 ml of 0.5 M zinc sulphate (dry) monoxide [$ZnSO_4 \cdot H_2O$] solution dropwise to 50 ml of 0.5 M sodium hydroxide solution within 30 minutes. The combined solution was then maintained at 25 °C for 2 hours while being vigorously stirred. The watery mixture becomes sticky, and the heavy precipitation settles to the bottom of the flask. After the mixture had been centrifuged, filtered, washed with water and alcohol, and dried at room temperature under vacuum for an additional day, the white precursor was finally collected for further characterization. The standard steps in the manufacture of ZnO nanoparticles are as follows: In order to create the alkali solution of zinc, 4.486 g of zinc sulphate (dry) monxide [$ZnSO_4 \cdot H_2O$] and 1 g of NaOH were dissolved in deionized water to create a 100 ml solution [Zn2+ = 0.5M, OH = 1.0 M].Then, a specific temperature was reached by heating the NaOH solution. The zinc sulphate (dry) monoxide solution was gradually added to the aforementioned alkali solution (dropwise for 30 min.) while being constantly stirred. The white precipitate that had accumulated at the bottom of the flask after the 2-hour reaction was removed and repeatedly cleaned with distilled water and 100% ethanol. After centrifuging and dehydrating the precipitate in a vacuum at 60–70 °C, the ZnO samples were finally obtained. By using this approach, around 90% of ZnO nanoparticles are produced.

RESULT AND DISCUSSION:

CHARTERSIATION

- FTIR (Fourier transform infrared spectroscopy)
- SEM (Scanning electron spectroscopy)
- XRD (X-ray diffraction analysis)

FTIR : The ZnO nanoparticles created by the sol gel technique do not exhibit any identifiable peaks in the monitoring range of the FTIR spectrum (Figure 1), which is used to evaluate the purity and composition of ZnO NPs. The created ZnO nanoparticles lost the broad band at 711 cm^{-1}. As a result of the production of ZnO nanoparticles, specifically zinc and oxygen bonding vibrations, another peak was created at 1052 cm^{-1}. The stretching of the carboxylic acid group along the C-O axis was indicated by the band at 1365 cm^{-1}. While the band discovered at 1595 cm^{-1} was probably related to the aromatic compounds' -C=C stretching. The secondary amine can be blamed for the weaker bands 2926 cm^{-1}. The O-H stretching of phenolic compounds may be responsible for the strong and wide band at 3432 cm^{-1}.

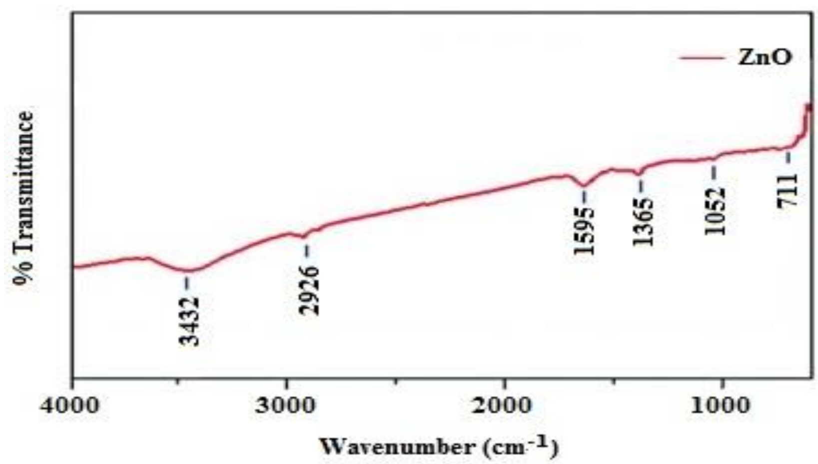
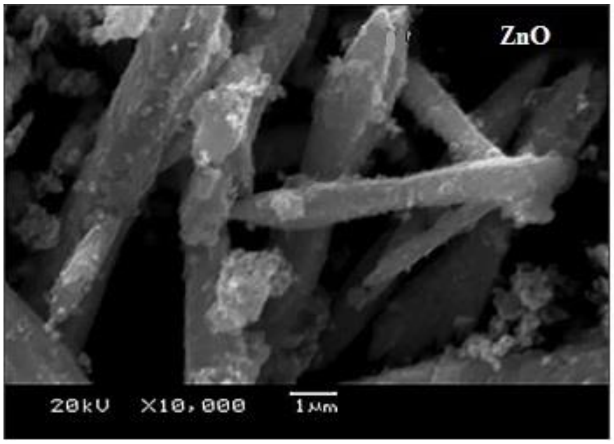


Figure : 1 FTIR Spectra of Zinc oxide Nanoparticles

SEM : Magnification and it shows that the particles are agglomerated and complete separation is not occurred. Its SEM image at higher magnification and we can see that the particles are held together because of weak physical forces. This indicates that zinc oxide prepared using zinc sulphate as the starting material does not produce particles with size in the nanometre range, as well as that the particle separation is poor and that this method of preparation was significantly impacted by particle agglomeration. Here, particles were formed with size in the micron range, whereas we want particles with size in the region of at least 100nm.

An picture of zinc oxide created utilising zinc sulphate (dry) monoxide as a starting material was captured using a scanning electron microscope (SEM) at a reduced magnification. Although the particles are only slightly agglomerated in this instance, the separation of the particles is still sufficient to demonstrate that the particles are being held together by physical force. The particle separation is enough, according to the SEM pictures of zinc oxide at higher magnification. The Nanorod was created in the SEM image.



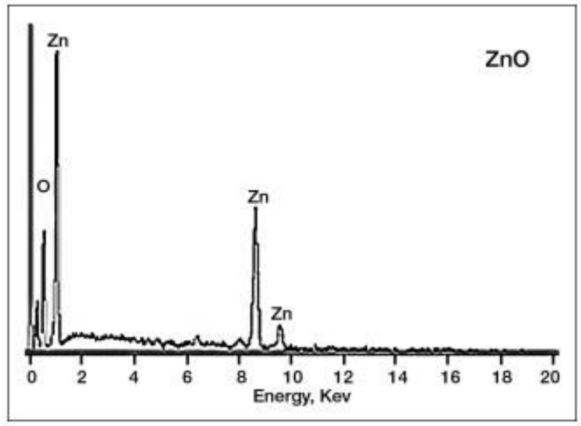


Figure : 2 SEM image of the Zinc oxide Nanorod under lower

XRD : Broad peaks at values of 100, 002, 101, 102, 110, 103, 200, 112, 201, 044, and 202, which are typical for the zinc oxide structure, can be seen in the XRD of the synthesised zinc oxide. The diffraction peaks' notable line broadening is a sign that the synthesised materials are in the nanometre range. Using Scherrer's equation, the full width at half maximum (FWHM) of the diffraction peaks have been used to calculate the average particle size. t = 0.9 /(B cos ş) is the formula for this, where is the x-ray wavelength and is the full width at half maximu m. It has been determined that zinc oxide nanoparticles have an average particle size of 25 nm.

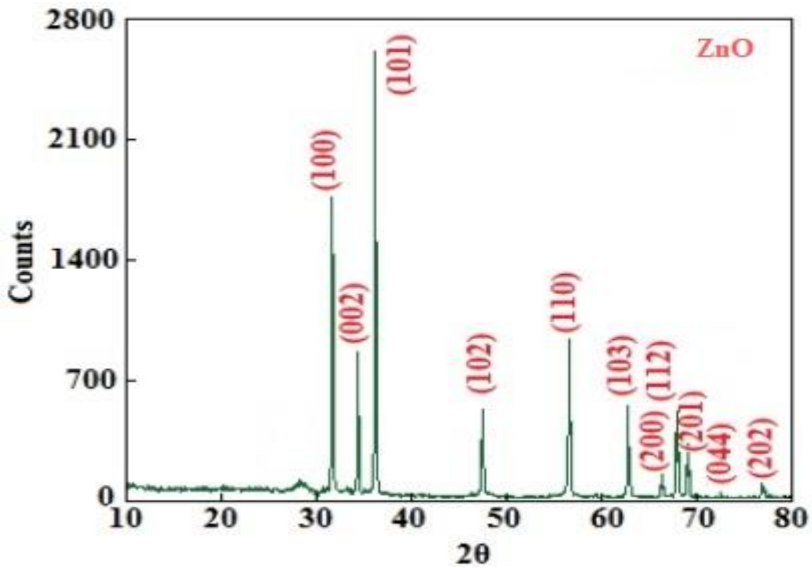


Figure 3. XRD spectrum of Nano zinc oxide prepared using PVA as surfactant

CONCLUSION

The ZnO nanorods (ZnONTs) have numerous applications in electrochemical biosensors. The related properties responsible included its biocompatibility, nontoxicity, fast electron-transfer rate, and easy application. ZnO nanostructures may be successfully combined with other materials by doping, generating nan composites, heterostructures and hybrid structures etc. allow obtaining the necessary parameters of nano biointerface. In our present study, concluded that biosensors applications of zinc oxide nanorods. FTIR spectrum of ZnO nanoparticles make absent the broad band at 711 cm^{-1}. The O-H stretching frequency has been found at 3432 cm^{-1}. During the SEM analysis, the particles were formed with size in the micron range and permitting to the SEM pictures of zinc oxide at greater magnification. In XRD investigations, discovered that zinc oxide nanoparticles have an average particle size of 25 nm. Using zinc sulphate (dry) monxide as the zinc source and NaOH as the precipitating agent in an aqueous solution, ZnO nanoparticles were successfully synthesised in this study. The size range of the ZnO nanoparticles produced. As a result of our successful efforts, we were able to create ZnO nanoparticles quickly and easily. Finally, FTIR, SEM, and XRD studies were used to characterise the ZnO nanoparticles. In our furthermore studies focused on found different biosensors applications of zinc oxide nanorods.

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REFERENCE

1. N. Høiby, O. Ciofu, H.K. Johansen, Z. Song, C. Moser, P.Ø. Jensen, S.Molin, M.Givskov, T. Tolker-Nielsen, T. Bjarnsholt, The clinical impact of bacterialbiofilms,Int. J. Oral Sci. 3 (2011) 55.

2. H. Šipova, S.L. Zhang, A.M. Dudley, D. Galas, K. Wang, J. Homola, Surface plasmon resonance biosensor for rapid label-free detection of microribonucleic acid at subfemtomole level, Anal. Chem. 82 (2010) 10110.

3. M. Simo, L. Simo, M.J. Vieira, A review of current and emergent biofilm control strategies, LWT-Food Sci. Technol. 43 (2010) 573.

4. M. Sundaram, S. Abirami, D. Rana, P. Vijayakumar, Tailored PVDF nanocomposite membranes using exfoliated MoS2 nanosheets for improved permeation and antifouling performance, New J. Chem. 41 (2017) 14315.

5. J.A. Callow, M.E. Callow, Trends in the development of environmentally friendly fouling-resistant marine coatings, Nat. Commun. 2 (2011) 210.

6. S. Palanichamy, G. Subramanian, Antifouling properties of marine bacteriocin incorporated epoxy based paint, Prog. Org. Coatings. 103 (2017) 33.

7. M. Nasrollahzadeh and S. Mohammad Sajadi, “Green synthesis of copper nanoparticles using Ginkgo biloba L. leaf extract and their catalytic

activity for the Huisgen [3+2] cycloaddition of azides and alkynes at room temperature," Journal of Colloid and Interface Science, vol. 457, pp. 141–147, 2015.

8. S. Sabir, M. Arshad, and S. K. Chaudhari, "Zinc oxide nanoparticles for revolutionizing agriculture: synthesis and applications," The Scientific World Journal, vol. 2014, Article ID 925494, 2014.

9. Liu, J. Ge, E. Ma and L. Yang, Advanced biomaterials for biosensor and theranostics, Biomaterials in translational medicine, Elsevier, 2019, pp. 213–255

10. S. K. Arya, S. Saha, J. E. Ramirez-Vick, V. Gupta, S. Bhansali and S. P. Singh, Recent advances in ZnO nanostructures and thin films for biosensor applications, Anal. Chim. Acta, 2012, 737, 1–21

11. M. L. M. Napi, S. M. Sultan, R. Ismail, K. W. How and M. K. Ahmad, Electrochemical-based biosensors on different zinc oxide nanostructures: A review, Materials, 2019, 12(18), 2985

12. P. Bedi and A. Kaur, "An overview on uses of zinc oxide nanoparticles," World Journal of Pharmacy and Pharmaceutical Sciences, vol. 4, no. 12, pp. 1177–1196, 2015.

13. M. Taheri, H. A. Qarache, A. A. Qarache, and M. Yoosefi, "The effects of zinc-oxide nanoparticles on growth parameters of corn (SC704)," STEM Fellowship Journal, vol. 1, no. 2, pp. 17–20, 2015.

14. L. R. Khot, S. Sankaran, J. M. Maja, R. Ehsani, and E. W. Schuster, "Applications of nanomaterials in agricultural production and crop protection: a review," Crop Protection, vol. 35, pp. 64–70, 2012.

15. Q. Chaudhry, M. Scotter, J. Blackburn et al., "Applications and implications of nanotechnologies for the food sector," Food Additives and Contaminants. Part A, vol. 25, no. 3, pp. 241–258, 2008.

16. P. J. P. Espitia, N. D. F. F. Soares, J. S. dos Reis Coimbra, N. J. de Andrade, R. S. Cruz, and E. A. A. Medeiros, "Zinc oxide nanoparticles: synthesis, antimicrobial activity and food packaging applications," Food and Bioprocess Technology, vol. 5, no. 5, pp. 1447–1464, 2012.

17. X. H. Li, Y. G. Xing, W. L. Li, Y. H. Jiang, and Y. L. Ding, "Antibacterial and physical properties of poly(vinyl chloride)-based film coated with ZnO nanoparticles," Food Science and Technology International, vol. 16, no. 3, pp. 225–232, 2010.

18. F. S.-S. Chien, C.-R. Wang, Y.-L. Chan, H.-L. Lin, M.-H. Chen, and R.-J. Wu, "Fast-response ozone sensor with ZnO nanorods grown by chemical vapour deposition," Sensors and Actuators, B: Chemical, vol. 144, no. 1, pp. 120–125, 2010.

19. Znaidi, Sol–gel-deposited ZnO thin films: A review, Mater. Sci. Eng., B, 2010, 174(1–3), 18–30