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Development and Characterization of ZnO-TiO_2 Nanocomposites for Enhanced Functional Applications

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Abstract - Zinc oxide and titanium dioxide have unique properties like low electron conductivity, antibacterial, anti-corrosion, and exceptional heat resistance, they are used extensively in modern industry. This study's goal is to use the sol-gel process to produce zinc oxide and TiO2 nanostructures in the most practical methods possible and then describe the nanostructures. The simplest method, the sol-gel method, uses systematic reaction parameter monitoring to control the size and shape of the particles. 3892 cm are the characteristic ZnO absorption bands. ZnO: TiO2 FTIR absorption spectra, which show a peak at 2426.45. By applying the Debye-Scherer formula, the crystalline size of the ZnO nanoparticle was determined. 3.7541 is the ZnO: TiO2 intensity, which is the appropriate intensity.

Keywords: $TiO_{2,\ ZnO}$ nanoparticle, Sol-gel method, UV, FTIR, XRD.

1.INTRODUCTION

anocrystalline materials are of great interest to researchers because of their special qualities and use in the creation of nanodevices. Zinc oxide (ZnO) has a nanometer-scale size and is utilized in a variety of applications, including gas sensors, pigments, non-linear optics, varistors, solar energy conversion, and cosmetics. ZnO material is becoming more and more in demand on the market every day for industrial uses such as UV filtering, catalysis, anti-corrosion, and antibacterial qualities. Citric acid was used as a complex reagent in a newly modified sol-gel process to synthesize the oxide photocatalyst ZnO/TiO2, and its photocatalytic activity was examined [1]. Because of their intriguing physical and chemical characteristics, as well as their potential for use in optoelectronics, chemical sensing, biosensing, and photocatalysis, ZnO nanoparticles have been the subject of intense investigation, according to Mondal et al. [3]. K. Ramachandran et al. synthesized TiO2/ZnO core/shell nanomaterials in two steps involving preparation of core TiO2 nanoparticles by simple hydrolysis and growth of ZnO shell layers on core TiO2 nanoparticles by refluxing methods [4]. ZnO nanomaterial was synthesized by the sol–gel method from an ethanol solution of zinc sulphate heptahydrate in the presence of diethylene glycol surfactant by Farahmandjou et al. [5-6]. Ayeshamariam et al. studied the photocatalytic and antimicrobial properties of the doped oxide materials by using the hydrothermal method [7]. The ZnO nanostructures were synthesized in simple ways using the sol-gel method [8]. Mohan et al. prepared ZnO nanomaterial using traditional methods and the preparation using surfactant [9-10]. This paper's first section outlines the many ways to manufacture ZnO nanomaterials using various precursors and modify their surfaces using polyvinyl alcohol. The TiO2/ZnO composite catalysts were produced by Liqin Wang et al. using a sol-gel technique. Additionally, XRD and FTIR techniques were used to assess the crystalline structure, morphology, thermal stability, and pore structure features. Sol-gel synthesis of the activated ZnO-TiO2 nanocomposite phosphors was successful, and X-ray diffraction, scanning electron microscopy, energy dispersive X-ray spectroscopy, Fourier transform infrared, UV-V spectroscopy, and X-ray photoelectron spectroscopy were used to characterize the products. Some methods of modifying ZnO thin films include atomic layer deposition, chemical sputtering, spray pyrolysis, electrochemical, and others [11]. This paper's first section outlines the many ways to manufacture ZnO nanomaterials using various precursors and modify their surfaces using polyvinyl alcohol. The TiO2/ZnO composite catalysts were produced by Liqin Wang et al. using a sol-gel technique. Additionally, XRD and FTIR techniques were used to assess the crystalline structure, morphology, thermal stability, and pore structure features. Sol-gel synthesis of the activated ZnO-TiO2 nanocomposite phosphors was successful, and X-ray diffraction, scanning electron microscopy, energy dispersive X-ray spectroscopy, Fourier transform infrared, UV-V spectroscopy and X-ray photoelectron spectroscopy were used to characterize the products. Some methods of modifying ZnO thin films include atomic layer deposition, chemical sputtering, spray pyrolysis, electrochemical, and others [11]. The band gap and electron tendency of ZnO nanoparticles are quite comparable to those of TiO2 [12]. Consequently, it is typical for the photocatalytic amount to be the same [13]. One of the most important semiconductors with strong photocatalytic activity was titanium dioxide (TiO2) [15]. The TiO2 material has primarily been employed as a photocatalyst, and AFM and SEM were utilized to analyze the production of TiO2 thin films [16–17]. At lower temperatures, TiO2 nanoparticles were described [18]. ZnO: 3.3 eV and TiO2: 3.2 eV have a broad bandgap [19–20]. These days, a variety of techniques are used in the solid phase, including the sol-gel method (solution method), vapor phase compression method, arc discharge, hydrogen plasma-metal reaction, and laser pyrolysis in the vapor phase, microemulsion, hydrothermal, and microbial processes occurring in the liquid phase, and ball milling. The several steps in the sol-gel technique used to create MONPs are depicted in Fig. 1. Gas sensors are among the many functions that ZnO has established [21].2. Body of Paper

The body of the paper consists of numbered sections that present the main findings. These sections should be organized to best present the material.

It is often important to refer back (or forward) to specific sections. Such references are made by indicating the section number, for example, "In Sec. 2 we showed…" or "Section 2.1 contained a description…." If the word Section, Reference, Equation, or Figure starts a sentence, it is spelled out. When occurring in the middle of a sentence, these words are abbreviated Sec., Ref., Eq., and Fig.

At the first occurrence of an acronym, spell it out followed by the acronym in parentheses, e.g., charge-coupled diode (CCD).

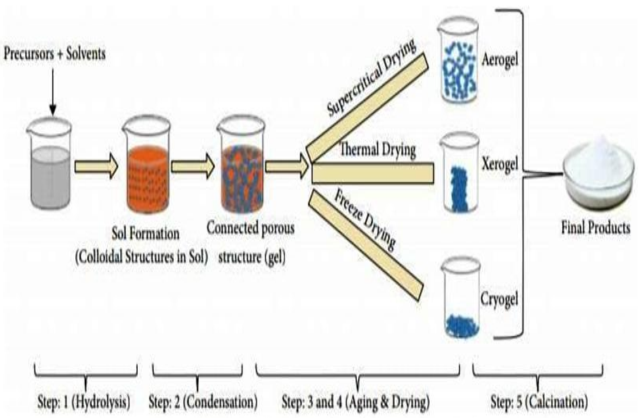

FIGURE 1: Schematic of different stages of sol-gel process: from precursor to aerogel [1–5].

Figure 1: Steps involved in sol–gel process to synthesize MONPs.

2. Experimental procedure: -

2 .1 Material and reagent: -

The sol-gel process was used to create the zinc oxide nanostructure. A weighting balance was used to weigh 20 g of zinc acetate dihydrate and 80 g of sodium hydroxide in order to create a sol. A measuring cylinder was then used to measure 10 and 15 milliliters of distilled water. By dissolving 2g mole zinc acetate dihydrate in 15 ml of distilled water and 8g (merk 99% purity) in 10 ml of distilled water, ZnO nanopowders were synthesized. For almost five minutes each, the solutions were continuously swirled. Once thoroughly combined, the sodium hydroxide solution was added to the zinc acetate solution while being continuously stirred for approximately five minutes using a magnetic stirrer. Next, 150 ml was placed in a burette.

2.2 Synthesis of zinc oxide (ZnO):

In the first breaker, mix 150 milliliters of distilled water with 20 grams of zinc acetate dihydrate. Then, in the second breaker, add 80 grams of sodium hydroxide (NaOH) to 100 milliliters of distilled water. String both materials for forty-five minutes. After stirring, the mixture is allowed to sit at room temperature for an hour. Additionally, each solution was added, stirred, and ethanol was added dropwise while being constantly steered at 60 C, stirred with a magnetic stir for 24 hours, and then left for 48 hours. A 100 ml amount of 0.1 m HCl (0.8825) solution was used to wash each of the white precipitate samples that were collected on filter paper (110 nm) following the reaction. ZnO powder was dried at 60 degrees Celsius till it became wet.

2.3 Preparation of TiO_2 nanoparticles: -

The co-precipitation process was used to create the TiO2 nanoparticles. Typically, a solution of ethanol and acetic acid was agitated for five minutes, and then titanium (IV) butoxide was added while being vigorously swirled for one hour. After two hours of aging, a precipitate formed from the resultant grey solution. After being dried for 24 hours at 60 °C in an oven, the precipitation was allowed to cool to room temperature. TiO2 material was finally prepared.

2.4 Synthesis of ZnO: TiO_2 nanocomposite:

The following procedure is used to synthesize ZnO+TiO2. Add 12 grams of zinc nitrate and 3.2 grams of NaOH to 50 milliliters of distilled water. After adding 1m (0.7986) of TiO2 to the beaker, it was swirled for one hour. After a while, ZnO was dissolved in distilled water, and TiO2 (0.7986m) was added to both solutions. The solutions were then mixed and left at room temperature for an hour before a dropwise addition of NaOH solution. Using a magnetic stirrer, the two solutions were combined, quickly swirled for two hours, and then polymerized for forty-eight hours. 48 hours later, the powder particles that had gathered on the filter paper (110 nm) were cleaned three or four times using a 100 ml amount of HCl at a 35% concentration.

3. Results and Discussion: -

3.1 Fourier Transform Infrared Spectroscopy (FTIR):

FTIR was used to characterize ZnO nanoparticles, which are displayed in Fig. 1. The sol-gel-synthesised ZnO nanoparticles' FTIR pattern, which was obtained in the 500–4000 cm-1 range. The C=O bonds are shown by the peak at 1500–1600 cm-1 in the typical FTIR spectra of pure ZnO nanoparticles. O-H bending vibrations are allocated to the adsorbed band at 3828 cm-1. The C=O and O-H bending vibrations are represented by the peaks at 3846 cm-1 and 3828 cm-1, respectively. As seen in Fig. 2, characterization absorption peaks are derived from the ZnO-TiO2 FTIR spectra. It was obtained between 500 and 4000 cm-1. Pure

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ZnO: TiO2 nanoparticles' typical FTIR spectra show a peak between 1500 and 1600 cm-1. The observed sharp peak is attributed to absorption bands.

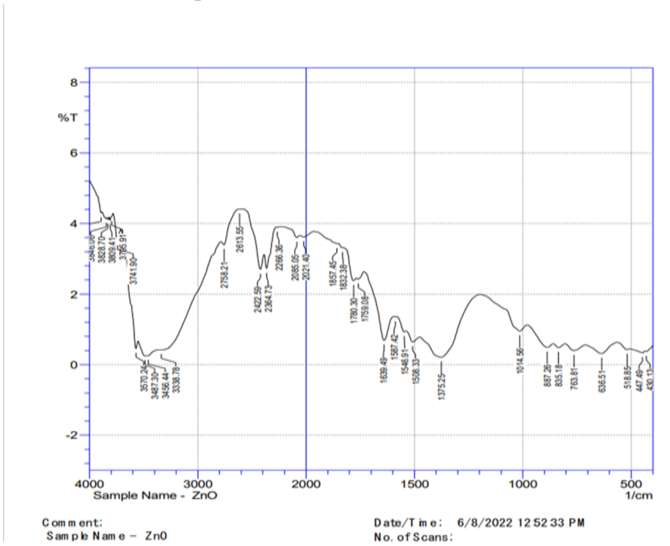

Fig -1: FTIR absorption spectra of ZnO

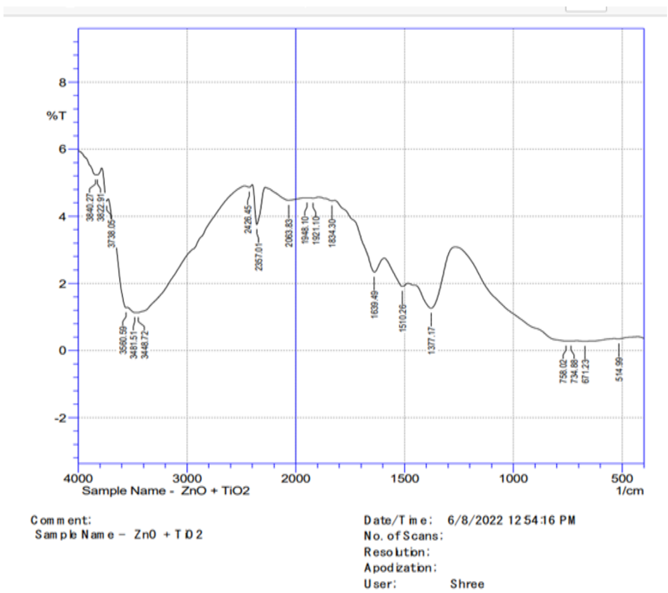

Fig -1: FTIR of ZnO and TiO_2 catalysts

3.2 X-ray Diffraction Spectroscopy

The sol-gel process is used to create the ZnO nanoparticle. The X-ray diffraction method was used to characterize the produced ZnO nanoparticles in powder form. Figure 3 illustrates the ZnO particle's crystalline nature. The XRD patterns in the 20–80° 2θ scan range were obtained using a monochromatic Cu Kα (λ=0.15405 nm) light source. Scherer's formula can be used to determine the crystalline size from XRD.

$$D= (0.9\lambda)/(\beta \cos\theta)$$

where λ is the incident X-ray wavelength (0.15405 A, CuKα), θ is the diffraction angle, β is the full-width half maximum, and D is the particle's crystallite size. The shape factor is "K." The pure ZnO structural form (JCPDS card No. 00-8103669) is represented by these values. The wavelength is 2θ = 6.46-57.76 degrees, with some low-intensity peaks.

X-ray diffraction patterns of ZnO and TiO2 powders in the broad range of 2θ of 32 to 100 are displayed in Fig. 4. In the 2θ range of a=3.242, b=3.2342, and c=5.1172, the peaks were visible. The ZnO and TiO2 particles have intensities of Alpha=900, Beta=900, and Gamma=1200.2θ is equal to 46.89. The peak with the highest intensity is (99.330). The hexagonal structure of wurtzite is referred to as ZnO's crystallinity.

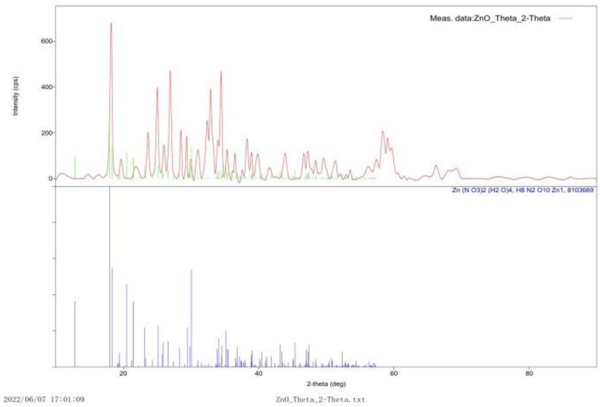

Fig -1: X-Ray Diffraction Pattern of ZnO Nanoparticle.

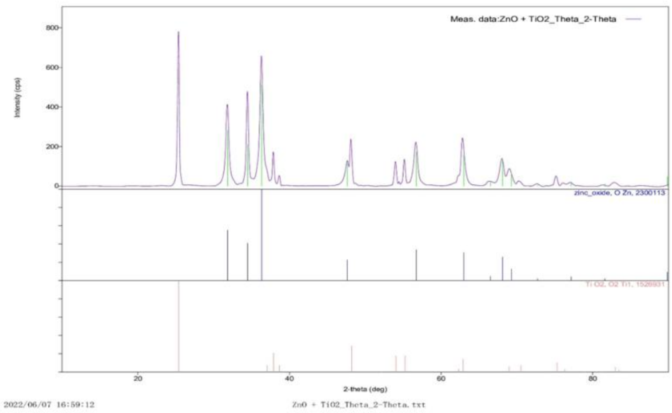

Fig -1:: X-Ray Diffraction Pattern of ZnO+ TiO_2

Nanoparticle

3. CONCLUSIONS

The current study examined commercial ZnO and ZnO produced using the sol-gel process. FTIR was obtained between 500 and 4000 cm-1. The peak at 2426.45 is the synthesis of ZnO FTIR absorption spectra of ZnO: TiO2. After calculation, the average crystallite sizes were determined to be

20 and 36 nm. The ZnO: TiO2 intensity is 3.7541, although 1.169 is the proper intensity. The ZnO and TiO2 nanoparticles that were produced show good crystallinity in the range below 1000 cm.

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