JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

PERFORMANCE ASSESSMENT OF STABILIZED SUBGRADE LAYER OF PAVEMENT

G Yakub[1], M.Harish Kumar[2]
[1]PG Student, Civil Department, Holy Mary Institute of Technology and Science, Hyderabad.
[2]Assistant Professor, Civil Department, Holy Mary Institute of Technology and Science, Hyderabad.

ABSTRACT:Due to its excellent material properties and appropriateness for constructing devices at the nanoscale scale, nanotechnology has today firmly established itself in numerous scientific and technological areas. Nanomaterials, of which nanoparticles are a subset, are defined as individual particles having a size between one and one hundred nanometers. Nanoparticles find widespread application in many domains, including sensing, optics, transmission, environmental protection, biology, medicine, cosmetics, and communications. The creation of innovative applications is made possible by nanoparticles' substantial optical, electrical, and magnetic properties. Among nanostructures, metal oxide nanoparticles stand out due to their great adaptability and diverse set of properties and capabilities. Nanoparticles of zinc oxide (ZnO) have shown great promise in a number of fields, including gas sensing, energy storage, optics, displays, solar cells, and drug delivery. Optoelectronic devices that rely on short-wavelength light find zinc oxide (ZnO) to be an extremely attractive material. This is because, at roomtemperature, it has a high exciton binding energy of 60 meV, a wide band gap of 3.37 eV, and strong bonding. An eco-friendly microwave-assisted wet chemical technique was used to create nanostructures of pure ZnO and Mo, Cr doped ZnO in this research. The next step was to investigate these nanostructures' gas sensing and magnetic properties. A series of zinc oxide (ZnO) nanorods with a dumbbell shape were synthesised by subjecting them to microwave irradiation for 5, 10, and 15 minutes. These nanorods outperformed the nanostructuresproduced at the other irradiation durations in terms of porosity. The material possesses diamagnetic characteristics, according to the magnetic studies. The sensor response time is also top-notch, and it works well across a hydrogen concentration range of 10–2000 ppm. In addition, its recovery times of 5 and 7 seconds are quite favourable. Furthermore, ZnO was doped with Mo at different weight percentages (3 wt.%, 5 wt.%, and 7 wt.%) to study their gas sensing and magnetic properties. The structural analysis showed that the Mo doped ZnO nanostructures are hexagonal. Moreover, the as-prepared nanostructures had an average crystalline structure size of around 25 nm, and the magnetic measurements, taken with VSM analysis, showed that the Mo doped ZnO exhibited ferromagnetism at room temperature. Synthesised utilising a microwave-assisted wet chemical technique, Cr-doped ZnO nanostructures showed a rise in magnetization values as the Mo concentration increased, showing a positive association with the concentration. The synthesis utilised varying amounts of Cr, particularly 3 wt.%, among others. five weight percent. as well as seven weight %, with a timing of 15 minutes for irradiation. Morphological and structural studies confirmed that the initial hexagonal (wurtzite) structure was preserved throughout the incorporation of chromium (Cr) ions into the ZnO crystal lattice. Our study centred on the practical applications of chromium-doped zinc oxide nanostructures as spintronic devices. The magnetic properties of the nanostructures suggest that Cr-doped ZnO is well-suited for spintronics applications, and the investigation of the VSM provided convincing validation of the ferromagnetic properties of Cr-doped ZnO nanostructures.

1 INTRODUCTION TO NANOTECHNOLOGY In recent years, nanotechnology has shown to be an invaluable tool in the production of numerous useful gadgets. This new field of study involves the design, fabrication, analysis, and application of materials on the nanoscale. It is possible to modify this technology such that it exhibits new and significantly improved biological, chemical, and physical properties. When an object's structural features fall somewhere between the size of individual atoms and that of bulk macroscopic materials—usually between 1 and 100 nanometers—intriguing and very useful behaviour ensues. Objects in thisrange can display physical characteristics that are very different from those of bulk materials and individual atoms. New technical opportunities and challenges may arise as a result of this. The high surface-to-volume ratio and the quantum confinement effect are the two main variables that explain the properties of nanomaterialsat the nanoscale. A variety of unique physiochemical and transport properties are associated with nanostructures, which are characterised by their extremely small size (usually between 1 and 100 nm). Optical, electrical, and sensing systems can be developed with the help of these nanostructures. A defining feature of nanomaterials is their extremely small size, defined as having a dimension of 100 nm or smaller. As films on a surface, as strands or fibres, or even as particles, these things can occupy one, two, or even three dimensions. Their morphologies can range from spherical to tubular to

irregular, and they can exist alone, in groups, or agglomerated. A few examples of common nanomaterials are fullerenes, quantum dots, and nanotubes.

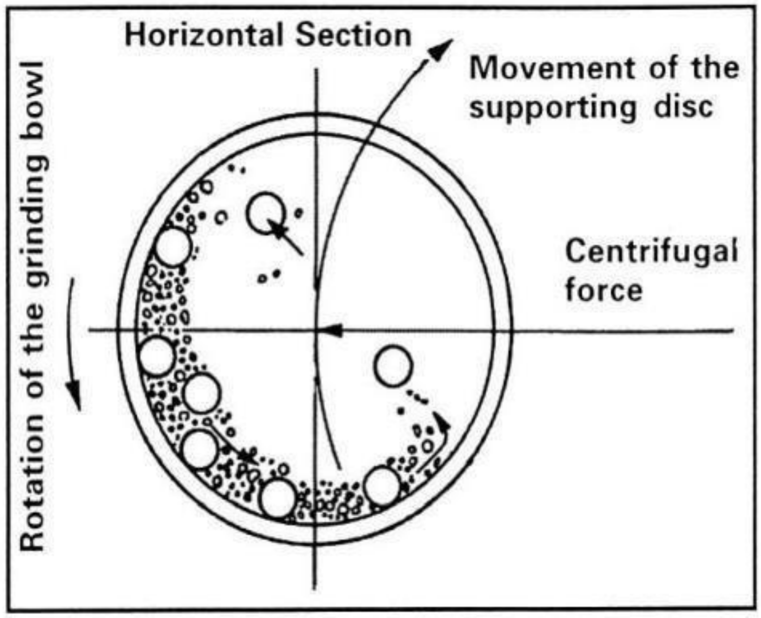
Nanoparticles are incredibly small particles with remarkable properties; their size is less than a significant length. This leads to the discretization of nanostructure electron states, which in turn produces unique and impressive nanoscale electrical, thermal, magnetic, optical, and mechanical properties. Nanostructures are intriguing because their physico-chemical properties can be tailored by controlling their size and shape on a microscopic scale. This results in the creation of new and improved apps. Researching nanostructured materials' extraordinary strength and malleability is important from a theoretical and practical standpoint. Fundamentally, our understanding of mechanical behaviour has been improved by learning about deformation mechanisms. Micromechanical devices and biomedical implants are only two examples of the many possible real-world uses for nanostructured metals and alloys. The fatigue resistance of a material can be significantly enhanced with the simultaneous enhancement of strength and ductility through the processing of nanoparticles. Nanomaterials' optical characteristics are mostly determined by their size, shape, surface characteristics, doping, and interactions with their environment. Because of the limited number of scattering centres and the amplified influence of electrons' wave-like nature (quantum mechanical effects), nanomaterials' electrical properties are subject to change. Nanoparticles bridge the gap between bulk materials and small molecules in terms of energy states; this dimensional categorization of nanotechnology

II.Literature Survey.Zinc Oxide is a crucial semiconductor material that possesses a broad energy gap of 3.3 electron volts and a substantial exciton binding energy of 60 milli-electron volts. Nanostructured zinc oxide playsa vital role in the production of innovative devices. Its exceptional chemical stability, biocompatibility, and lack of toxicity make it very suitable for a wide range of applications, including Optoelectronics, solar cells (as a window layer and n-type electrode), sensors, biotechnology, and engineering. Due to its ability to be quickly modified by adding suitable dopants, it is considered the most adaptable material. Currently, there are several synthesis processes developed specifically for creating ZnO structures for distinct device applications.

Considerable efforts have been focused on improving or altering the characteristics of ZnO to suit diverse applications. Doping was employed as a means to enhance the characteristics of ZnO. The tunable optical and electrical properties of metal-doped ZnO have garnered significant attention. Furthermore, the impact of different metallic additives and the temperature at which ZnO material is synthesised on its morphology has not been clearly understood. Therefore, it is crucial to comprehend the impact of metal dopants on the characteristics of ZnO nanostructures. Tani et al. (2002) used flame spray pyrolysis to create ZnO nanoparticles. The nanoparticles were found to have a hexagonal phase with an average particle size ranging from 10 to 20 nm. Zeng et al. (2003) produced Sb-doped ZnO nanoparticles with a wurtzite structure using the vapour condensation process. The average size of the grains was determined to be 60 nm. The XPS analysis showed the presence of antimony (Sb) incorporated into the crystal structure of zinc oxide (ZnO). The introduction of doped Sb^{5+} ions into ZnO nanoparticles results in an increase in both optical reflectivity and electrical resistivity compared to undoped nanoparticles. Researchers Jinmin Wang and Zhang et al. (2007) successfully synthesised single crystalline ZnO nanowires with a diameter of approximately 80- 100 nm using a wet chemical method. These nanowires exhibited exceptional UV

SYNTHESIS AND CHARACTERIZATION TECHNIQUES OF NANOSTRUCTURES

Scientists' interest in nanotechnology and nanomaterials has skyrocketed in the last several years. Nanoparticle synthesis is a hotspot for study in academia and, even more so, in the field of applied nanotechnology. There have been major advancements in the methods used to synthesise different types of nanostructures, thanks to the work of scientists. According to Shibata et al. (1998), numerous physical and chemical methodologies have been devised to improve the performance of nanomaterials. These methodologies have demonstrated enhanced properties of nanomaterials, with the goal of achieving better control over particle size and distribution.Synthesising the necessary nanostructures with the desired morphology, particle size distribution, purity, quantity, and quality using environmentally safe and cost-effective methods was the greatest challenge researchers encountered. The numerous approaches to synthesising nanostructures of zinc oxide are well- documented.Producing nanoparticles of varying geometries and dimensions is made easy with this energy- efficient and resilient synthesis process. The process involves the transmission of kinetic energy from moving balls to the material being milled. Because of this, the chemical links between the milled materials are broken, and the materials are ruptured into smaller particles with freshly formed surfaces. A number of factors influence the physical and morphological characteristics of the nanomaterials that are produced, including the milling speed, ball-to-powder weight ratio, milling type (dry or wet), milling atmosphere, milling duration, and the amount of energy transferred between the balls and the material. According to Chimolaet al. (2016), high energy ball milling can be regarded as a mechano chemical synthesis process due to the extremely high local temperatures (>1000 °C) and pressures (several GPa) that are occasionally involved.



(Source: Suryanarayana *et al.* (2001))

Figure 3.1The motion of balls in a planetary ball mill from

Inert Gas Condensation Method for Synthesis Nanoparticle synthesis originally relied on inert gas evaporation.Evaporation occurs when a substance is exposed to low pressure, on the order of 1 mbar, in a cool, inert gas such as Helium or Argon. The inert gas convective flow goes over the evaporation source and carries the nanoparticles that have produced above the source to a surface that has been chilled with liquid nitrogen by thermophoresis. Some common processes for vaporisation include sputtering, resistive evaporation, and laser evaporation. Nanoparticles can be mass-produced in an apparatus that does not expose them to air by utilising a scraper and a collecting funnel. These nanoparticles are agglomerated without forming hard agglomerates and can be compressed within the device. Birringer and Gleiter were the

first to use this approach. Particles in an inert gas will grow in average size as their pressure or molecular weight rises. Many different materials are currently being processed commercially using this so-called Inert GasCondensation technique. Adding oxygen to the inert gas allows for reactive condensation, which can result in ceramic particles of nanoscale. An alternative approach involves substituting a hot- wall tubular reactor for the evaporation boat and introducing an organometallic precursor in a carrier gas. Chemical vapour condensation is the name given to this process because, unlike inert gas condensation, it involves chemical interactions.

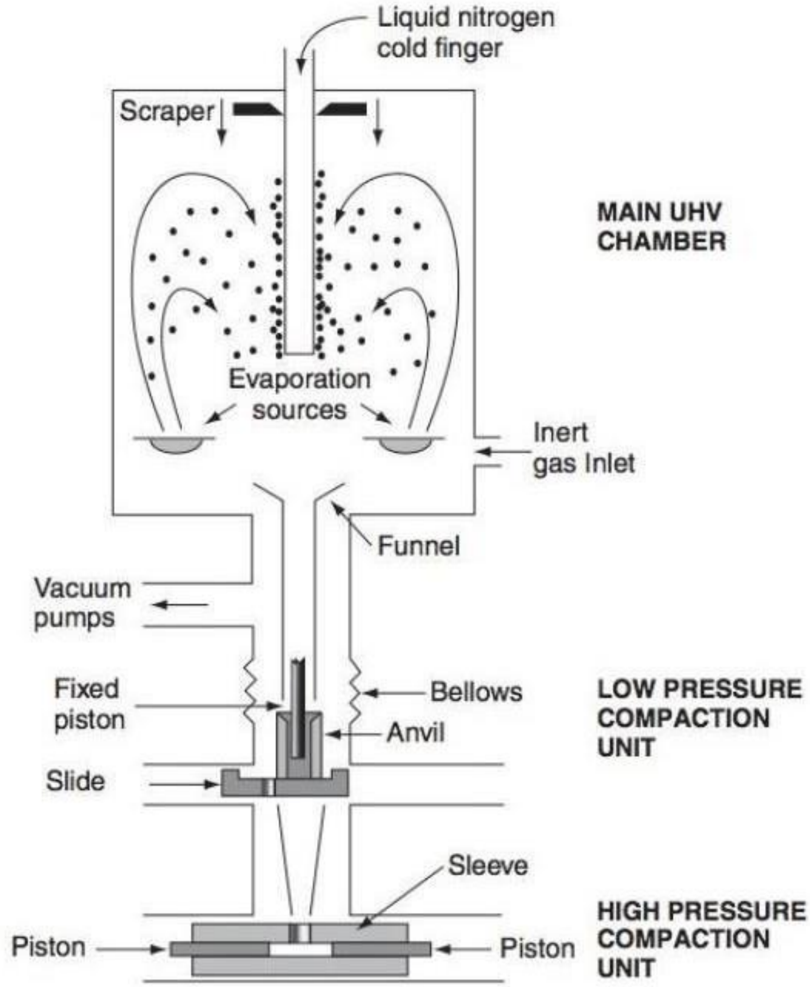
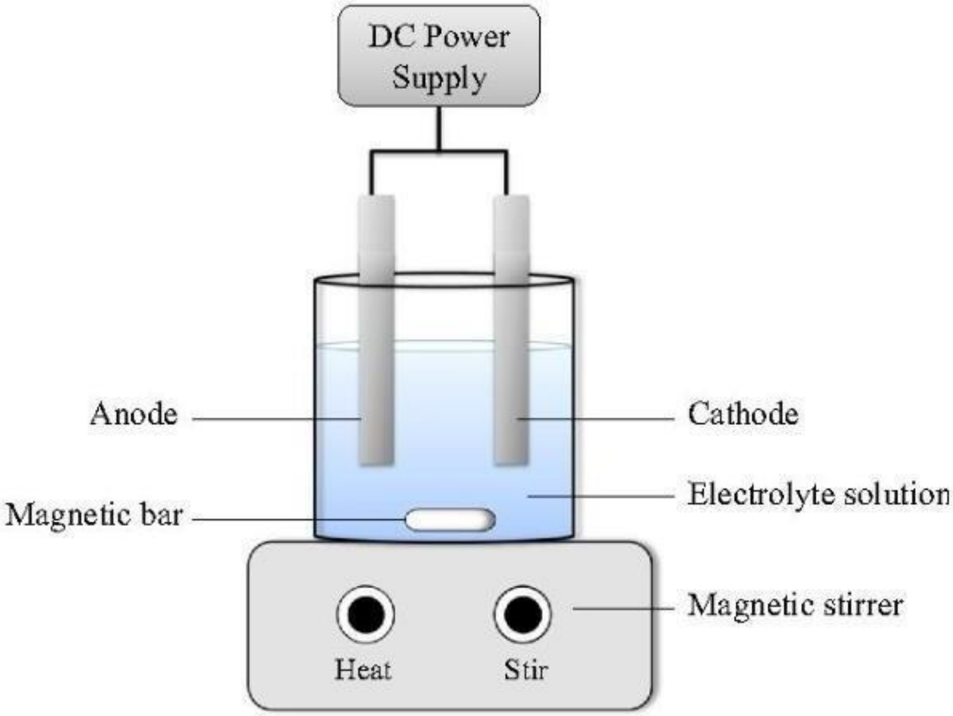


Figure 3.2Inert Gas Condensation Technique Setup

Electrochemical Method A specific amount of electric current can flow through an electrolyte that separates two electrodes in an electrochemical synthesising process. At the contact between the electrode and the electrolyte, the synthesis process occurs, with electricity serving as the driving force. Electrochemical methods have many benefits over their physical counterparts, such as being inexpensive, easy to operate, very flexible, requiring lessequipment and instruments, having less pollution,

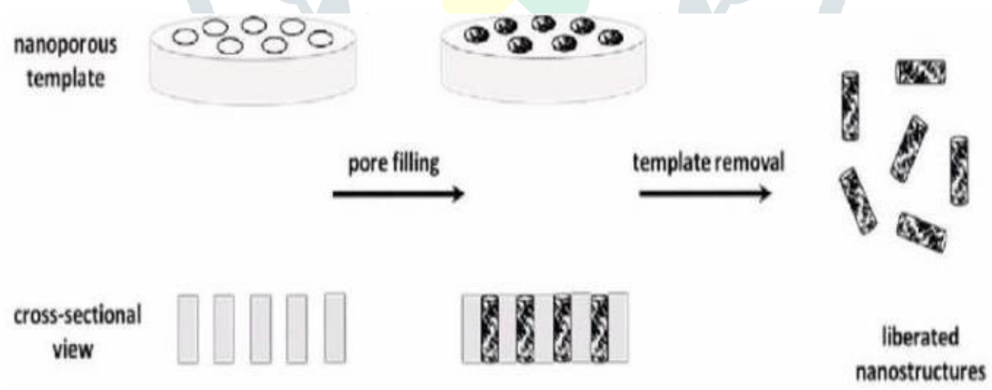
and being environmentally benign.In order to advance both fundamental knowledge and practical applications, the electrochemical approach has been the subject of more research, as stated by Brahman et al. (2012).



(Source: Ramimoghadam *et al.* (2014))

Figure 3.3. Typical Electrochemical synthesising setup

Templating In order to prepare a wide range of nanostructure materials, the template method has recently grown in popularity.This technique makes use of the morphological features with reactive deposition or dissolution to build materials that resemble known characterised materials (templates) in terms of their morphology. Therefore, by manipulating the morphology of the template material, a plethora of novel materials with a regular and regulated nanoscale morphology can be created.



(Source :Karatas& Hilal Algan (2017))

Figure 3.4 Schematic representation of template synthesis method from

1.1.1 Chemical Vapour Deposition (CVD) A key function of CVD in the semiconductor industry is the production of thin films with high performance and purity. The substrate is usually subjected to volatile precursors in a conventional CVD procedure, and the film is created by their reactionand/or decomposition on the surface of the substrate. It is common practice to use gas flow through the reaction chamber to eliminate volatile byproducts. According to Kim et al. (2004), precursor concentration, reaction rate, and temperature have a significant impact on the deposited material quality. The homogeneous coating of nanoparticles or nanofilm is the main benefit of this approach. But Sudarshan (2003) laid forth the process's shortcomings. Additionally, he brought out the fact that the method necessitates higher temperatures and is challenging to scale up.

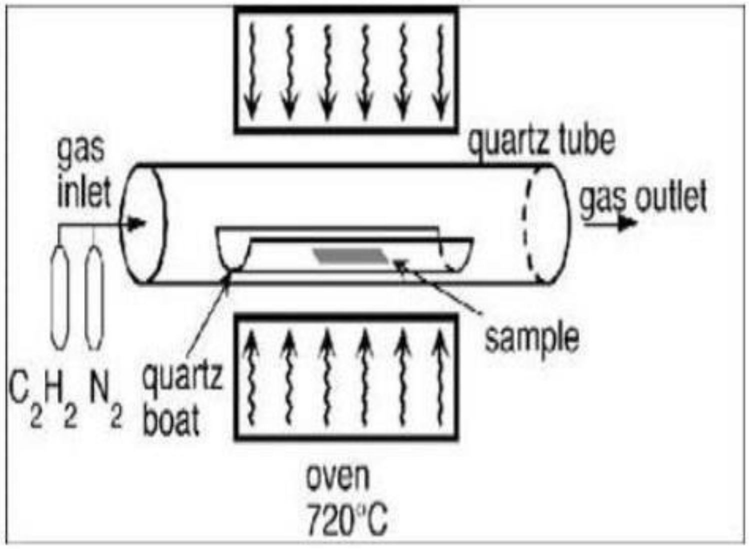


Figure 3.5Typical Chemical Vapour Deposition method setup

3.INVESTIGATION OF STRUCTURAL AND MAGNETIC PROPERTIES OF MOLYBDENUM DOPED ZNO NANOSTRUCTURES PREPARED BY MICROWAVE-ASSISTED WET CHEMICAL METHOD

1.1 INTRODUCTION The existence of oxygen vacancies in zirconium oxide makes it an appealing semiconductor oxide material with a broad bandgap (Kishimotos et al., 2006). Due to its important capabilities with varied surface morphologies, doped ZnO or ZnO combined with other oxides are now widely used in gas sensors, energy storage devices, and photocatalysts in numerous industrial domains (Jayanti et al., 2010; Raid et al., 2006).Dopant effects on ZnO nanostructures have received scant attention in the literature. While the crystalstructure remains unchanged, the dopant modifies several of zinc oxide's properties, including its electrical, magnetic, and optical characteristics. Zinc oxide was doped with a number of elements for various uses, including aluminium [Kim et al., 2000; InKotlyarchuk, et al., 2005; Hoffman et al., 2003], among others. With its intriguing speculier characteristics, such as being a direct wide bandgap semiconductor, relatively chemically stable, having a high refractive index, and possessing magnetic and electronic properties, Mo is among the most suitable metal oxides among the dopants [Cho et al. (2014); Waters et al. (2003); Yao et al. (1992)]. Because Mo6+ and Zn2+ have ionic radii of 0.062 and 0.083 nanometers, respectively, Mo6+ may hypothetically replace Zn2+ in the ZnO lattice. Because of the large valence difference between Mo6+ ions and substituted Zn2+ ions, Mo is the more advantageous impurity and, when doped into a ZnO matrix, it

can provide four electrons to the free carriers. Several elements, including cadmium (Baiet al., 2014), iron (Ouyang et al., 2012), cerium (Jinet al., 2014), erbium (Ren et al., 2014), and indium (Chen et al., 2011), were doped into molybdenum. For applications in spintronic and magnetic-optic devices, it is recognised that materials having semi-conductive characteristics and room temperature ferromagnetism are necessary. Adding ZnO to Mo can enhance its electrical conductivity, transparency, and room temperature ferromagnetism, opening up exciting possibilities for use in spintronic and magnetic-optic devices. This research makes use of a microwave- assisted wet chemical approach to dope Mo with ZnO. Due to its simplicity, speed, cost- effectiveness, and energy-saving properties, the microwave approach has been the subject of extensive research into ZnO nanoparticles. This is because it allows for the easy scaling up of the manufacture of very pure and crystalline ZnO nanostructures (2013).According to Amir Kajbafvala et al. (2010) and Virendra Chandore et al. (2013), the radiation cycles and ideal power were used to synthesise Mo-ZnO nanostructures because of the potential impact on product structure and attributes. Using a battery of characterization tools, we systematically investigate how Mo doping affects the magnetic, structural, and morphological characteristics of ZnO nanoparticles. 1.2 Demonstration Method We created a zinc acetate solution with a concentration of 0.1M and then, while stirring constantly, neutralised it with liquid ammonia (pH-8). Then, a home microwave was used to irradiate the solution for 15 minutes after it was made. The precipitates that were collected contained water

molecules that were dried on a heated plate. Using a muffle furnace set to 120C, the dehydrated samples were heated. We gathered the finished good and marked it as (A).

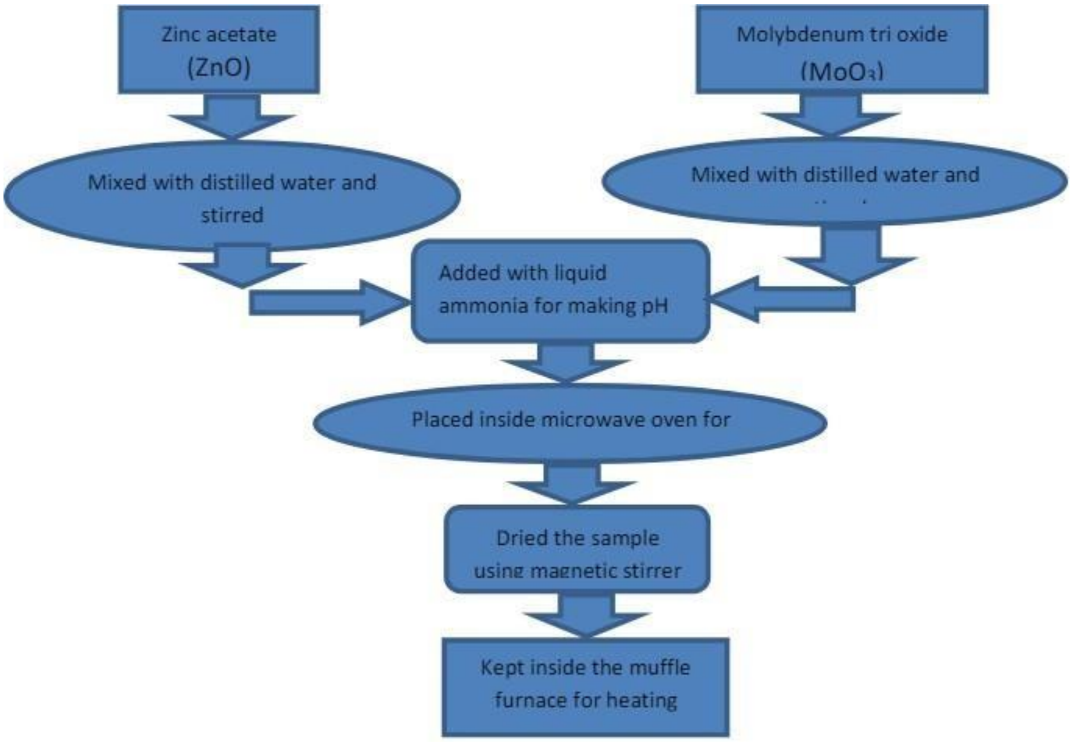


Figure5.1Schematic diagram of synthesis of molybdenum doped ZnO

In addition, MoO3 was doped with ZnO in the following proportions: 1 weight percent, 3 weight percent, 5 weight percent, and 7 weight percent. Afterwards, the zinc acetate solution was combined with 0.1M of molybdenum oxide solution in the aforementioned ratios. Prior to being subjected to microwave irradiation for fifteen minutes, the solution was vigorously stirred for one hour. After meticulously collecting all of the precipitates, they were dried on a hot plate to eliminate any remaining water molecules. For two hours, the dried samples were gently heated in a

muffle furnace to 120C. The finished products were designated as Mo1ZnO for samples with 1 weight percent MoO3 doped ZnO, Mo3ZnO for samples with 3 weight percent MoO3 doped ZnO, Mo5ZnO for samples with5 weight percent MoO3 doped ZnO, and Mo7ZnO for samples with 7 weight percent MoO3 doped ZnO. Figure
5.1 shows the schematic of the synthesis method for molybdenum doped ZnO nanopowder.

1.3 ADDRESSION AND OUTCOME 1.3.1 X-Ray Diffraction Figure 5.2 shows the X-ray diffraction patterns of unsaturated and Mo-doped ZnO nanostructures. The diffraction peaks that are distinctive of ZnO were carefully observed and indexed. The nanostructures that were produced exhibit a hexagonal arrangement that is in agreement with the JCPDS card number: 89-1397, with the assumed orientation being
(101). Characteristic ZnO peaks, including (100), (002), (101), (102), (110), (113), and (112), were visible throughout the pattern. Curiously, the absence of a molybdenum peak indicates that the Mo compound has been adequately doped with ZnO. In addition, the XRD patterns show that there is just one phase, Mo-dopedZnO nanoparticles, and no other oxides. Furthermore, as can be observed in Figure, the peak intensity of ZnO has been significantly impacted by Mo doping. A few minor peaks in Figure, as well as Mo5ZnO and Mo7ZnO.As the percentage of Mo compounds was increased, ZnO, Mo1ZnO, and Mo3ZnO were demised. Using Scherrer's formula, we were able to estimate the crystallite size D of the ZnO-Mo nanostructure. As indicated in Table (5.1), the nanoparticle crystallite diameters varied between 12 and 25 nm for samples of Mo-doped ZnO with varying ratios.

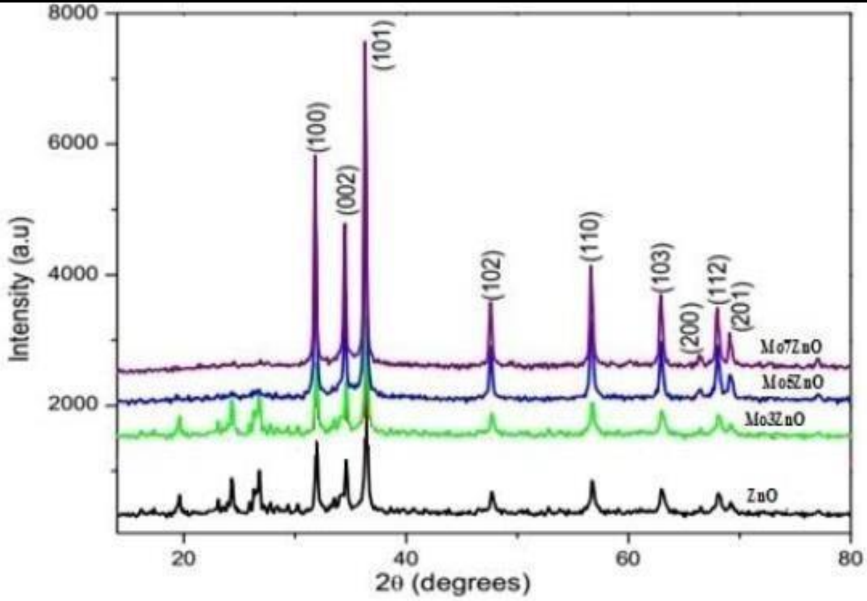


Figure 5.2XRD

pattern of pure ZnO and Mo-doped ZnO nanostructures

Table 5.1 XRD Analysis of undoped and Mo doped ZnO nanostructures

S.no	Sample	Average particle size in nm	d spacing (θ)
1	ZnO	35.44	2.82036
2	Mo1ZnO	31.32	2.81266
3	Mo3ZnO	28.84	2.81265
4	Mo5ZnO	27.89	2.81110
5	Mo7ZnO	27.66	2.80268

The FT-IR spectra of the Mo-doped and pure ZnO nanostructures (Mo1ZnO, Mo3ZnO, Mo5ZnO, and Mo7ZnO) that were synthesised are displayed in Figure
5.3.The prior reports were concordant with the measured transmittance peaks. Zeolite bond stretching vibrationsare responsible for the 456 cm-1 peak. The presence of MoO3 was indicated by peaks at approximately 558 cm-1, 677 cm-1, and 1816 cm-1. Water adsorbed onto the catalyst surface is responsible for the bending vibration, which is indicated by the peak at 1627 cm-1. A Mo-O- Zn bond may have formed, which would explain the signal at 1341 cm-1. The stretching mode of Mo=O is indicated by the absorption bands at 931 cm-1. Sampath et al. found that the FTIR spectra's detected peaks were very congruent with their reported findings. that year (2012)

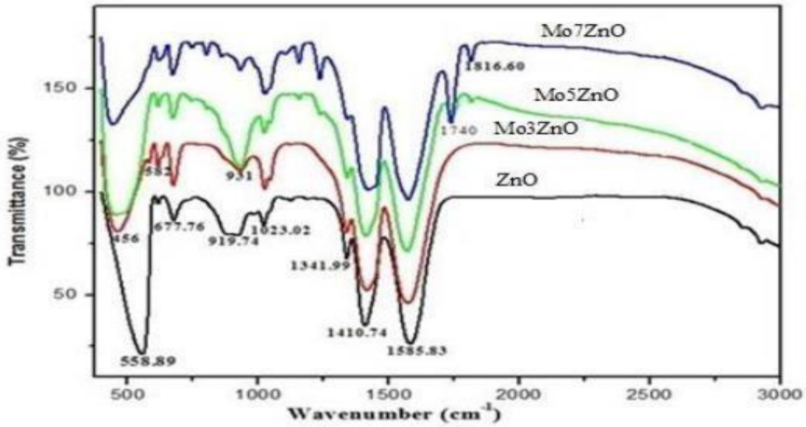


Figure 5.3 FTIR analysis of pure ZnO and Mo-doped ZnOnanostructures

CONCLUSION Wet chemical synthesis was used to produce molybdenum doped ZnO and undoped ZnO of varying concentrations. Researchers looked at how Mo doping ZnO nanoparticles changed their shape, size, andmagnetic characteristics. A hexagonal structure with a preferred orientation of (002) is shown by the XRD studyof Mo-doped ZnO nanoparticles.The as-prepared samples were found to contain MoO3 due to the transmittance peaks identified in the FTIR study.The microscopic examination showed that the surface shape of the ZnO nanoparticle is changed by microwave irradiation, which creates hotspots, and by different percentages of Mo doping. Optical investigations show that when the Mo doping concentration increases, the bandgap values fall and the band edge shifts towards lower wavelengths. Research using VSM at ambient temperature was performed to get insight into the magnetic characteristics. When tested, all of the samples showed ferromagnetism at room temperature. It was discovered that the specific magnetization values increased as the Mo concentration increased.

References

1. Abdel–Aziz, G., & El Sayad, H. I. (2002). Effect of Retempering on Consistency, Compressive Strength and Durability Related Properties of OPC, Silica Fume and Fly Ash Concrete in Egypt. Civil Engineering Research Magazine, Civil Eng. Dept., Al-Azhar University, Cairo, Egypt, 24(4), 1460- 1477.

2. Abdel–Aziz, G., & El Sayad, H. I. (2002). Effect of Retempering on Consistency, Compressive Strength and Durability Related Properties of OPC, Silica Fume and Fly Ash Concrete in Egypt. Civil Engineering Research Magazine, Civil Eng. Dept., Al-Azhar University, Cairo, Egypt, 24(4), 1460- 1477.

3. Abrishami, H. H., & Mitchell, D. (1996). Analysis of bond stress distributions in pullout specimens. Journal of Structural Engineering, 122(3), 255-261.

4. ACI Committee 408, 2003 ―Bond and Development of Straight Reinforcing in Tension ACI 408R-03),‖ American Concrete Institute, Farmington Hills, MI, , 49 pp

5. Ahmad, S., & Alghamdi, S. A. (2014). A statistical approach to optimizing concrete mixture design. The ScientificWorld Journal, 2014.

6. Alnaki, A. A., Wegian, F. M., Abdalghafar, M. A., Alotaibi, F. A., Ali, I. A., Almurshed, M. M., & Alwan, A. B. (2014). Assessment of the Strength of Remixed Concrete Structures. Jordan Journal of Civil Engineering, 8(2), 227-238.

7. Baigrai, N.K. arid Kar, J. N.(1970) "Effect of pre setting of cement on the mortar strength" Cement and Concrete,Apr-June, pp 25-29.

8. Bairagl, N.K. and Jhaveri (1977). "Strength variation of composite mixes by pure selfing theory" Indian Concrete Journal, March,pp 87-89.

9. Bairagi, N., Strength Variation of Composite Mixes by General Selfing Theory, Int. Conference on Materials ofConstruction for Developing Countries, Bangkok. August 22-28, 1978 at AIT-Bangkok, Thailand.

10. Bairagi, N.K., Goyal,A.S.and Joshi,P.A.(1989) "Strength of Composite Mixing Using General Crossing Theory" ICJ, Vol.63, No.12,pp 600-604. 232 | P a g e

11. Bairagi, N.K. ,Goyal, A.S, and Ramachandra RAO,M. (1990). "Selfing and Crossing Theories on CumulativelyCured Strength", ICJ, Vol. 64, No.11, Nov., pp 527-534.

12. Bayrak, M. B., & Ceylan, H. (2008). Neural network-based approach for analysis of rigid pavement systems usingdeflection data. Transportation Research Record, 2068(1), 61-70.

13. Bezabih, A. G., & Chandra, S. (2009, July). Comparative study of flexible and rigid pavements for different soil and traffic conditions. In Journal of the Indian Roads Congress (pp. 153-162).

14. Buch, N., & Zollinger, D. G. (1996). Development of dowel looseness prediction model for jointed concrete pavements. Transportation research record, 1525(1), 21-27.

15. Byrum, C. R. (2013). Falling Weight Deflectometer Evaluation of Pavement Joint Looseness and Differential Slab Edge Settlements in Jointed Concrete Pavements. In Airfield and Highway Pavement 2013: Sustainable and Efficient Pavements (pp. 243-261).

16. Chen, D. H., Won, M., & Hong, F. (2009). Investigation of settlement of a jointed concrete pavement. Journal of performance of constructed facilities, 23(6), 440-446.