Literature Review on Synthesis of ZnO Nano Particles Using Natural and Synthetic Methods

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Abstract: **Nowadays many efforts have been made for achieving ZnO Nanoparticles through the various approaches to obtain desired shapes. The present paper discussed about these methods such as Microemulsions, molucualr beamepitaxcy, spray pyrolysis, common thermal evaporation, and chemical varour methods. The present paper portrays a brief review of the methods that have been used for synthesize and characterizes Zinc Oxide nanoparticals**

Key words: **Zinc Oxide, nanoparticals, Nanoparticles Microemulsions**

I. INTRODUCTION

Nanomaterials are particles having nano scale dimension, and nanoparticles are very small sized particles with enhanced catalytic reactivity, thermal conductivity, non-linear optical performance and chemical steadiness owing to its large surface area to volume ratio. NPs have started being considered as nano antibiotics because of their antimicrobial activities. Nanoparticles have been integrated into various industrial, health, food, feed, space, chemical, and cosmetics industry of consumers which calls for a green and environment-friendly approach to their synthesis.

II. NANOPARTICLE SYNTHESIS METHODS

Two approaches have been suggested for nanoparticle synthesis: Bottom up and top down approach. The top–down approach involves milling or attrition of large macroscopic particle. It involves synthesizing large-scale patterns initially and then reducing it to nanoscale level through plastic deformation. This technique cannot be employed for large scale production of nanoparticles because it is a costly and slow process. Inter ferometric Litho- graphic (IL) is the most common technique which employs the role of top–down approach for nanomaterial synthesis. This technique involves the synthesis of nanoparticles from already miniaturized atomic components through self-assembly. This includes formation through physical and chemical means. It is a comparatively cheap approach. It is based on kinetic and thermodynamic equilibrium approach. The kinetic approach involves MBE (Molecular Beam Epitaxy).

III. ZINC OXIDE NANOPARTICLES

Agarwal et al., (2017) study reveals that various inorganic metal oxides can be manufactured such as TiO_2, CuO, and ZnO, among these manufacturing of ZnO is economic.

US Food and Drug Administration (US FDA) identified ZnO as one of the good semiconductors because of its good band gap it can be used as cosmetics like sunscreen lotions, anti-cancer, anti- diabetic, antibacterial, antifungal because of its UV filtering Properties. In addition to this ZnO is used for targeted drug delivery even though it has the limitation of cytotoxicity which is yet to be resolved. ZnO also been employed for rubber manufacturing, paint, for removing sulfur and arsenic from water, protein adsorption properties, and dental applications. ZnO NPs have piezoelectric and pyro-electric properties. They are used for disposal of aquatic weed which is resistant to all type of eradication techniques like physical, chemical and mechanical means. ZnO NPs have been reported in different morphologies like nano-flake, nano-flower, nano-belt, nano-rod and nano-wire.

IV. LITERATURE STUDY

Karam et al., (2018) conducted an experiment on TiO_2 coated ZnO nano crystals and came to a conclusion that the change of the total active surface area is uniform and single way for PS 5 microns. But, in the PS 1 microns, the uniformity is broken due to the active surface depends on how much quantity we are adding TiO_2 NPs. We can still say that the active surface increases by increasing the number of layers or increasing the TiO_2 NPs layer thickness.

Kumari et al., (2015) studied influence of nitrogen doping on structural and optical properties of ZnO nano particles.Un-doped and N doped ZnO nano particles were synthesized by using chemical precipitation method. The prepared samples were differentiated through X-Ray Diffraction technique (XRD), Transmission Electron Microscopy(TEM) equipped with Energy Dispersive X-ray (EDAX) spectroscopy, UV–visible spectroscopy, Fourier Transform Infrared(FTIR) and came to a conclusion that the formation of impurity free wurtzite phase for undoped and N doped samples was uncertain through XRD analysis. The crystallite size was found increasing with increase in N doping concentration.

Rochman et al., (2017) explained the synthesis of ZnO nanoparticles made by Sol-Gel method. The process parameters used are variations in pH, in increasing order, of

7to 12, in steps of 1 by using two principal reactions method to produce compound oxide, such as hydrolysis and condensation by considering Sodium hydroxide as an agent. Research reveals that greater the pH of the sol-gel will increase the agglomeration of particle and vice-versa.

Datta et al., (2017) research conducted to check the potential of Parthenium hysterophorus leaf extracts for the extraction of zinc oxide nanoparticles for their anti-microbial properties. Nanoparticles were extracted with the help of aqueous, methanolic and ethanolic solutions. Synthesised nanoparticles were distuinguised using UV-V is spectroscopy with maximum absorbance peak at 400 nm. SEM and TEM analysis illustrate the particles were spherical and cylindrical in shape with average particle size ranging between 16-45 nm.

Sutradhar et al., (2016) study used green synthesis of zinc oxide nanoparticles (ZnO) by thermal method and under microwave irradiation using the aqueous extract of tomatoes as non-toxic and also nature-friendly reducing material .They concluded that microwave-assisted green chemistry has been used for the preparation of ZnO NPs. A facile approach has been reported using tomato extract, acting as reducing agent for the synthesis of ZnO NPs of well-defined dimensions in huge amount. This eliminated the need of toxic chemicals for the production of nanoparticles. The synthesis has been done by thermal process as well as under microwave irradiation using different power and the synthesized nanoparticles was successfully used to prepare nano-composites for photovoltaic application.

Mohan, et al.,(2016) conducted a study on the preparation of zinc oxide nanoparticles using conventional process and the preparation using surfactant and with characterization of the prepared zinc oxide using Scanning Electron Microscopy (SEM) and X-Ray Diffraction in order to find out which method is more feasible in terms of particle agglomeration, particle size, particle separation**.** They stated that zinc oxide nanoparticles were successfully prepared with and without using surfactants. The characterization results it's clear that the conventional method of preparation highly affected by particle agglomeration and also the particle separation is not good enough. And the most important thing is that the particle size of zinc oxide prepared using PVA is in the nano meter's range whereas in conventional method of preparation particle size in the micron range.

Mclaren et al., (2009) study illustrated the photolytic activity of ZnO crystals and states that it would be better to deduce the specific photo-catalytic activity of a particular crystallographic plane (100, 101, 001) if one could compare quantitatively its surface area. Such quantitative analysis could be compared with photo-catalytic behaviour of ZnO surfaces made using UHV methods. Since these process of ZnO fabrications have shown a pronounced effect on size and shape dependent catalytic activity.

Ahmed et al., (2017) depicts the Structural, optical, and magnetic properties of Mn-doped ZnO samples deals with the microstructure, optical, and magnetic properties of Zn1_xMnxO powder samples with x = 0.02–0.08 synthesized by a solid-state reaction method. X-ray diffraction showed that the cell characteristics between a and c, increased with the increase in Mn content, which showed that Mn ions substitute into the lattice of ZnO. It states that Mn-doped ZnO nano-powders have been successfully prepared by a solid-state reaction route. XRD studies showed the incorporation of Mn into the ZnO lattice. UV–v is measurements showed that the band gap decreased due to the decrease in incorporation of Mn. PL studies confirmed the formation of VO in all the samples. Magnetic measurements revealed that all the samples exhibited RTFM, and the average magnetic moment per Mn atom decreased with the increase both in the Mn content and TA. However, the structural, optical and magnetic investigations showed that FM observed at room temperature is an intrinsic property of the ZnO: Mn powder samples due to VO and defects, and it does not originate from any secondary magnetic phase or cluster formation.

Thaweesaeng et al.,(2013) research explained Pure ZnO and Cu - doped ZnO nano-powders (1, 2, 3, 4 and 5 wt% Cu) were synthesized by co-precipitation method without further post-heat treatment .It reveals that's synthesized ZnO and Cu-doped ZnO nano powders have been successfully prepared using co-precipitation technique. The XRD results confirmed that the crystal structure of all not synthesized samples is hexagonal wurtzite with a average crystallite sizes is approximately 25-27 nm corresponding to inter-planar spacing, lattice constant and micro-strain of as-synthesized powders.

Khalil et al., (2014) research reports that ZnO nanoparticles were obtained by thermal decomposition of a binuclear zinc (II) curcumin complex as single source precursor. Research explained that low heat energy was applied to degrade the organic moiety. Nanoparticles with a size ranging from 117± 4 nm were obtained from an easily prepared organic moiety consisting metal complex precursor. Such a type of precursors has potential for synthesizing metal oxide nanoparticles.

Sutradhar et al.,(2015) research conducted on the synthesis of zinc oxide (ZnO) nanoparticles and its composite with natural graphite (NG) powder for application in solar cells working. ZnO nanoparticles were prepared using green tea leaf extract as non-toxic and eco-friendly reducing material under microwave irradiation. A facile approach has been reported using green tea leaf extract, acting as reducing agent for the synthesis of ZnO nanoparticles of well-defined dimensions in bulk amount. Excellent reproducibility of these nanoparticles, without using any additional capping agent or stabilizer, will have a huge advantage as compared with microbial extraction, avoiding all the difficult and hygienic problems. ZnO nanoparticles were successfully used to produce thin film of ZnO/NG composite material for photovoltaic application.

Hasnidawani et al.,(2016) study conducted to synthesize zinc oxide nanostructures with the most practical ways by making use of sol-gel method and characterize the nanostructures. The zinc oxide nanostructure was successfully synthesized by using sol-gel process. Result revealed that the ZnO rod like structure was successfully synthesized by sol gel method in nano-size range about 84.98nm and exhibit good crystallinity.

Jiang et al., (2018) argued that Zinc oxide nanoparticles (ZnO NPs) are used in an increasing number of industrial products such as rubber, paint, coating, and cosmetics. ZnO NPs have exhibited promising biomedical applications based on its anticancer, antibacterial, anti-diabetic, anti-inflammatory, drug delivery, as well as bio-imaging activity. Due to inherent toxicity of ZnO NPs, they possess strong inhibition effects against cancerous cell and bacteria, by inducing intracellular ROS generation and activating apoptotic signaling pathway, which makes ZnO NPs a potential candidate as anticancer and antibacterial agents. In addition, ZnO NPs have also been well known to promote the bioavailability of therapeutic drugs or biomolecules when functioning as drug carriers to achieve enhanced therapy efficiency. Moreover, with the ability to decrease blood glucose and increase in insulin levels, ZnO NPs have shown the promising potential in treating diabetes and attenuating its complications, which can be further evaluated.

Wang (2004) research exhibits that using solid–vapour phase thermal sublimation technique, nanocombs, nanorings, nanohelixes/nanosprings, nanobelts, nanowires and nanocages of ZnO have been synthesized under specific growth conditions. ZnO is a semiconducting, piezoelectric and pyroelectric material. Utilizing individual nanobelts, devices and applications have been demonstrated for field effect transistors, gas sensors, nanoresonators and nanocantilevers. These derives will have important applications in nanosystems and biotechnology.

Matinise et al., (2017) research conducted to develop a better and reliable process for the bio-fabrication of Zinc oxide nanoparticles through green method using Moringa Oleifera extract as an effective chelating agent and concluded, Zinc oxide nanoparticles with particle size raging from 12.27 and 30.51 nm have been successfully synthesized natural by Moringa-oleifera extract and characterized using different methods. The XRD and EDS studies have shown that an annealing at about 500◦C in air is required for the synthesis of pure wurtzite ZnO phase. This was stated via the XRD investigations shed-lighting on the polycrystalline nature of the nanoparticles.

Alenezi et al.,(2014) research emphasizes on the path for structure induced enhancement of gas sensing performance by designing a desirable nanostructure, which could also be extended to synthesize other metal oxide nanostructures with superior gas sensing performance. As a result it concludes, novel hierarchical ZnO structures built by growing secondary ZNWs with controllable density on initial 1D and 2D ZnO nanostructures have been produced on a vast scale through a simple and economical hydrothermal process. Control experiments reveal that the formation of these hierarchical structures is based significantly on the concentration of the growth solution as well as the growth time and PEI concentration. Essentially, the grown hierarchically structured ZnO has displayed a strong structure induced enhancement of gas sensing performance with a much better sensitivity toward acetone and fast response compared to other mono-morphological ZnO, such as ZnO nanoparticles, nanorods, and nanosheets. This is primarily attributed to their high surface-to-volume ratio, increased strength of active (0001) exposed facts as well as the formation of the secondary NW–initial nanostructure junctions. These hierarchical ZnO structures are also expected to be useful for other applications such as dye-sensitized solar cells and photo-catalysis.

Sindhura et al.,(2013) study explained the biogenic zinc nanoparticles were synthesized using the leaves of Parthenium hysterophorous by green synthesis method. UV–VIS absorption spectroscopy was used to monitor the quantitative formation of zinc nanoparticles. The properties of the synthesized zinc nanoparticles were studied using scanning electron microscopy and nanoparticle analyzer. Zinc nanoparticles were seen to be spherical in shape with size ranged between 16-108.5 nm. They came to a conclusion that the zinc nanoparticles were synthesized using *Parthenium hysterophorous* leaf extract by green synthesis method. The optical absorption peaks recorded at 327.50 and 330.00 nm confirms the formation of zinc nanoparticles. The estimated particle size was 16.10–58.60 nm, grain size was 108.50 nm and zeta potential was 100.40–117.20 mV, respectively. Sample-1 (100 %) exhibited maximum zeta potential and minimum particle size. The enzyme and microbial activities and physiological traits were tested with the help of sample-1, which resulted in significant variations among the nanoparticles treated samples compared to the control. The potential microbial activity of as prepared zinc nanoparticles is different variety. Zinc nanoparticles coupled with microbial activity promises potential applications in agriculture where zinc is one of the essential micronutrients which is need to be supplied to the crop plants.

Alias et al., (2010) concluded that ZnO nanoparticles were processed at different pH values by the sol–gel process and centrifuged at 3000 rpm within 30 minutes. The ZnO powders agglomerate when synthesized in acidic and neutral conditions (pH 6 and 7).They stated that Fine powders were obtained when the pH of the sols was increased to 9. The maximum crystallite size of the ZnO powder was obtained at pH 9. The particles sizes of the ZnO synthesized ranged between pH 6 and 11 were in the range of 36.65–49.98 nm. Ultraviolet–visible studies (UV–vis) also revealed that ZnO processed ranging from pH 8 to 11 has good optical properties with band gap energy (*Eg*) between 3.14 and 3.25 eV.

Bora et al.,(2011) research conclude that Zinc oxide (ZnO) nano-rods decorated with gold (Au) nanoparticles have been processed and used to fabricate DSSE- dye-sensitized solar cells. The pico-second resolved time-related/dependent single-photon-count TSCPC spectroscopy technique was used to study the charge-transfer mechanism in the ZnO/Au-nano composite DSSC. Due to the formation of the Schottky barrier at the ZnO/Au interface and the higher optical absorptions of the ZnO/Au photo-electrodes arising from the surface plasmon absorption of the Au nanoparticles, enhanced power-conversion efficiency (PCE) of 6.49% for small-area (0.1 cm^2) ZnO/Au-nano composite DSSC was achieved compared to the 5.34% efficiency of the bare ZnO nanorod DSSC. They concluded that incorporation of Au nanoparticles into the ZnO-nano rod photo-electrode led to higher optical absorption by the photo-electrode and high dye intake, resulting in an ~35% enhancement in the photocurrent in the case of the ZnO/Au-nano composite DSSC (active area = 0.1 cm^2) with J_{sc} equal to 14.89 mA/cm^2 compared to the bare ZnO-nanorod DSSC with J_{sc} equal to 11.01 mA/cm^2. As a result, the overall power-conversion efficiency was increased ranging from 5.34%- 6.49% for the small-area (0.1 cm^2) .

Sangeetha et al.,(2011).reported on the production of nanostructure zinc oxide particles by both chemical and biological process. Highly stable and spherical zinc oxide nanoparticles are produced by using zinc nitrate and Aloevera leaf extract and stated that greater than 95% conversion to nanoparticles has been achieved with aloe leaf broth concentration greater than 25%. Structural, morphological and optical properties of the synthesized nanoparticles have been characterized by using UV–Vis spectrophotometer, FTIR, Photoluminescence, SEM, TEM and XRD analysis. SEM and TEM analysis shows that the zinc oxide nanoparticles prepared were poly dispersed and the average size ranged between 25 to 40 nm. The particles obtained have been found to be predominantly spherical and the particle size could be controlled by varying the concentrations of leaf broth solution.

Jain et al., (2013) study concluded that a positive correlation between zinc metal tolerance ability of a soil fungus and its potential for the synthesis of zinc oxide (ZnO) nanoparticles. A total of 19 fungal cultures were isolated from the rhizospheric soils of plants naturally growing at a zinc mine area in India and identified on the genus, respectively the species level available. Aspergillusaeneus isolate NJP12 has been shown to have a maximum zinc metal tolerance ability and a potential for extracellular synthesis of ZnO nanoparticles under ambient conditions. UV–visible spectroscopy, Fourier transform infrared spectroscopy, X-ray diffraction analysis, transmission electron microscopy, and energy dispersive spectroscopy studies further confirmed the crystallinity, morphology, and composition of synthesized ZnO nanoparticles. Their results revealed the synthesis of spherical nanoparticles coated with protein molecules which served as stabilizing agents. Investigations on the role of fungal extracellular proteins in the synthesis of nanoparticles indicated that the process is nonenzymatic but involves amino acids present in the protein chains.

Rao et al.,(2016) stated that study has been to use a biologically mediated, low temperature approach for the synthesis of zinc oxide nanoflowers. “Green” methods have a number of advantages over conventional approaches; these include the use of environmentally benign reactants and its economic feasibility. The cell free extract of Chlamydomonas reinhardtii, a fresh water microalga was used to synthesize the nanoflowers. The nanoflowers were composed of individual nanorods that assembled to form flower-like structures. The nanorods measured 330 nm in length and these nanorods self-assembled to form porous nanosheets that were found to measure 55–80 nm. Particle size analysis revealed that the larger porous nanoflowers approximately measured 4 µm. Powder X-ray diffraction studies revealed that the zinc oxide nanoflowers had a hexagonal wurtzite crystal structure. Fourier transform infrared spectroscopy analysis suggested that algal biomolecules were responsible for the synthesis and stabilization of zinc oxide nanostructures. These nanoflowers demonstrate enhanced photocatalytic activity against methyl orange (MO) under natural sunlight.

Hameed et al.,(2016) pure ZnO and Neodymium (Nd) doped ZnO nanoparticles (NPs) were synthesized by the co-precipitation method. The synthesized nanoparticles retained the wurtzite hexagonal structure. From FESEM studies, ZnO and Nd doped ZnO NPs showed nanorod and nanoflower like morphology respectively. The FT-IR spectra confirmed the Zn-O stretching bands at 422 and 451 cm^{-1} for ZnO and Nd doped ZnO NPs respectively. From the UV-VIS spectroscopic measurement, the excitonic peaks were found around 373 nm and 380 nm for the respective samples and concluded that from the FESEM images, the pure and doped samples were found to exhibit nanorod and nanoflower like morphologies respectively. From the EDAX analysis, the chemical compositions were estimated for the prepared samples. From the recorded FT-IR spectra, the various vibrational frequencies were assigned for the pure ZnO and Nd doped ZnO NPs samples. The band gap of ZnO and Nd doped ZnO NPs were estimated as 3.34 and 3.26 eV from the UV-Vis spectroscopic measurements. The photoluminescence studies showed that the doping with ZnO NPs altered the band emission due to zinc vacancies, oxygen vacancies and surface defects.

Pulit-Prociak et al.,(2016) study presents a method for functionalization of textile materials using fabric dyes modified with silver or zinc oxide nanoparticles. Embedding of these nanoparticles into the structure of other materials makes that the final product is characterized by antimicrobial properties. Indigo and commercially available dye was involved in studies. It is worth to note that silver nanoparticles were obtained in-situ in the reaction of preparing indigo dye and in the process of preparing commercial dye baths. Such a method allows reducing technological steps. The modified dyes were used for dyeing of cotton fibers. The antimicrobial properties of final textile materials were studied. Saccharomyces cerevisiae strain was used in microbiological test and concluded that the results confirmed biocidal activity of prepared materials.

Bagabas, et al.,(2013).This paper deals with a simple, fast, cost-effective, room-temperature wet chemical route, based on cyclohexylamine, for synthesizing zinc oxide nanoparticles in aqueous and enthanolic media was established and tested for the photodegradation of cyanide ions. The paper concludes that Zinc oxide nanoparticles were readily prepared at room temperature from zinc nitrate hexahydrate and cyclohexylamine either in aqueous or ethanolic medium. The calcined ZnOE had a regular, polyhedra morphology while the calcinedZnOW had irregular spherical morphology, mixed with some chunky particles. The morphology was a key factor in the superior photocatalytic behavior of ZnOE over that of ZnOW. The differences in morphology and photocatalytic behavior are strongly influenced by the physicochemical properties of the synthesis medium.

V. CONCLUSION

Zinc oxide nanoparticles (ZnO) have advantages because of its physical, chemical properties, its usage and manufacturing methods. To manufacture this ZnO leads to increases in pollution and environmental hazardous, this paper exhibits the both natural and artificial synthesis of ZnO using different method.

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