

GREEN SYNTHESIS OF ZnO NANOPARTICLES USING *Abrus precatorius* SEEDS EXTRACT AND THEIR CHARACTERIZATION

*Thesis submitted to Department of life science for the partial fulfillment of the
M.Sc. Degree in Life science*

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CERTIFICATE

This is to certify that the thesis entitled “**GREEN SYNTHESIS OF ZnO NANOPARTICLES USING *Abrus precatorius* SEEDS EXTRACT AND THEIR CHARACTERIZATION**” which is being submitted by **Mrs. Kavita Vishwakarma** Roll No. **411LS2069**, for the award of the degree of Master of Science from National Institute of Technology, Rourkela, is absolutely based upon his work carried out under my supervision. The results embodied in this thesis are new and have not been submitted to any other university or institution for the award of any degree/diploma.

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DECLARATION

I do hereby declare that the Project Work entitled “**GREEN SYNTHESIS OF ZnO NANOPARTICLES USING *Abrus precatorius* SEEDS EXTRACT AND THEIR CHARACTERIZATION**”, submitted to the Department of Life Science, National Institute of Technology, Rourkela is a faithful record of bonafide and original research work carried out by me under the guidance and supervision of Dr. Suman Jha, Asst. Professor, Department of Life Science, National Institute of Technology, Rourkela, Odisha.

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D. ABBREVIATION

NPs: Nanoparticles

Hrs : Hours

Mins : minutes

ZnO: zinc oxide

SEM: Scanning electron microscope

FTIR: Fourier transform infrared spectroscopy

DLS: Dynamic light scattering

XRD: X-ray diffraction

mV: millivolt

E. ABSTRACT

In modern science Nanotechnology is a ablaze field for the researchers. Nanoparticles having a size of 1-100 nm in one dimension, is used significantly concerning medical chemistry, atomic physics, and all other known fields. Nanoparticles are used immensely due to its small size, orientation, physical properties, which are reportedly shown to change the performance of any other material which is in contact with these tiny particles. These particles can be prepared easily by different chemical, physical, and biological approaches. But the biological approach is the most emerging approach of preparation, because, this method is easier than the other methods, ecofriendly and less time consuming. The semiconductor ZnO has gained substantial interest in the research community in part because of its large exciton binding energy 60 meV which could lead to lasing action based on exciton recombination even above room temperature. The Green synthesis was done by using the aqueous solution of *Abrus precatorius* seeds extract and zinc acetate. A fixed ratio of plant extract to metal ion was prepared and the color change was observed which proved the formation of nanoparticles. The nanoparticles were characterized by UV-vis Spectrophotometer, FTIR, DLS, Zeta Analysis, XRD, and SEM. The particles synthesized were of the size ranging from 90-500 nm.

INTRODUCTION

Nanotechnology emerges from the physical, chemical, biological and engineering sciences where new techniques are being developed to probe and maneuver single atoms and molecules for multiple applications in different field of scientific world. In nanotechnology, a nanoparticle is defined as a small object that behaves as a whole unit in terms of its transport and properties. The science and engineering technology of nanosystems is one of the most exigent and fastest growing sectors of nanotechnology [1].

In the recent years, due to the advancement in Science and technology researchers have attempted to synthesize nanoparticles within the size range of 100 nm and this extensive research and concern on nanoparticles is widening due to their potential application in wide areas of science and technology. ZnO belongs to the class of metal oxides, which is characterized by photo catalytic and photo-oxidising capacity against chemical and biological species [2].

The progress of technology and quality of life of mankind has always been closely knit with the progress in material science and material processing technology. Most techniques applied in material processing are based on breaking up large chunk of a material into desired shapes and sizes, inducing strain, lattice defects and other deformations in the processed material. Recent developments and findings in nanotechnology and the demonstration based on various quantum size effects in nanoscale particles, reveals that most of the novel work and devices of the future will be based on properties of nanomaterials. Each nanoparticle contains only about $3 \cdot 10^7$ atoms/molecules. The traditional material processing techniques that induce lattice defects and other imperfections will no longer be diluted for synthesis of nanoparticle by unmitigated number of atoms. Furthermore, the application of traditional approach imparts difficulties for synthesis of such small particles in a desirable size range.

Alternative synthetic technique for nanoparticles involves controlled precipitation of nanoparticles from precursors mixed and dissolved in a solution. A micro suspension can also be formed using surfactants between two immiscible liquids, with the reactionary isolated inside a colloid, through hydrophobic versus hydrophilic forces. The resultant nanoparticles form a micro colloidal suspension. Various factors such as thermodynamic determinant as well as van der Waal's forces induce particle growth and accumulation, resulting in bigger particles that settle down over time. A contingency in utilizing colloidal nanoparticles is that its stability is

maintained in colloidal suspension. The mechanism involved in stabilization of nanoparticles can be categorized as a) electrostatic stabilization: involving the creation of a double layer of adsorbed ions over the nanoparticles resulting in a coulombic repulsion between approaching nanoparticles; or b) Steric hindrance: achieved by adsorption of polymer molecules over the nanoparticles. Polymer molecules coated with nanoparticles feel osmotic repulsion when these particles approach each other which occurs due to localized increase in their concentration and hence keeps them (along with the nanoparticles) well separated.

Nature has devised various processes for the synthesis of nano and micro- length scaled inorganic materials which have contributed to the development of relatively new and largely unexplored area of research based on the biosynthesis of nanomaterials. Synthesis using bio-organisms is congruent with the green chemistry principles. “Green synthesis” of nanoparticles makes use of environmental friendly, non-toxic and safe reagents.

To the best of our knowledge, biological approach using milky latex of *Calotropis procera* has been used for the first time as a reducing material as well as surface stabilizing agent for the synthesis of spherical-shaped ZnO-NPs. The structure, phase, and morphology of synthesized product were investigated by the standard characterization techniques. Spherical ZnO NPs have been synthesized using milky latex of *Calotropis procera* and apart from this ZnO particle with high stability and spherical shape have also been synthesized using *Aloe vera* extract.

The “green” route for nanoparticle synthesis is of great interest due to eco-friendliness, economic prospects, feasibility and wide range of applications in nanomedicine, catalysis medicine, nano-optoelectronics, etc. It is a new and emerging area of research in the scientific world, where day-by-day developments is noted in warranting a bright future for this field. Zinc oxide is an inorganic compound with the formula ZnO. It is usually insoluble in water and appears as a white powder. The powder is widely used as an additive into numerous materials and products including plastics, ceramics, glass, cement, rubber (e.g. car tyres), lubricants, paints, ointments, adhesives, sealants, pigments, foods (source of Zn nutrient), batteries, ferrites, fire retardants, etc ZnO is present in the Earth crust as a mineral zincite; however, commercially used ZnO is produced synthetically. Zinc and oxygen belong to the 2nd and 6th groups of the periodic table respectively and therefore in materials science, ZnO is often called a II-VI semiconductor. This semiconductor has several favorable properties: good transparency, high electron mobility, wide bandgap, strong roomtemperature luminescence, etc. ZnO with several favourable properties are

already used in emerging applications for transparent electrodes in liquid crystal displays and in energy-saving or heat-protecting windows, and electronic applications of ZnO as thin-film transistor and light-emitting diode are forthcoming as of 2009 [3].

REVIEW OF LITERATURE

Nanotechnology may be the next big thing in science, and before long we will probably find ourselves immersed in it. It has attracted considerable attention in the scientific community ever since its emergence as a powerful basic and applied science tool. Nanotechnology provides the tools and technology platform for the investigation and transformation of biological systems, and biology offers inspiration models and bio-assembled components to nanotechnology. Nano biotechnology is defined as a field that applies the nanoscale principle and techniques to understand and transform bio systems (living and non-living) and which uses biological principles and materials to create new devices and systems integrated from the nanoscale [4]. Key advances have been made in the ability to make measurements at the sub-cellular level and in understanding the cell as highly organized, self-repairing, self-replicating, information-rich molecular machines [5] and [6]. Smalley, classified nanotechnologies into wet and dry nanotechnology, the first one describes the living bio systems and the second one deals with man-made objects at nanoscale structures [7]. The presence of nanoparticles in commercially available products is becoming more common.

Nanoparticles, according to the ASTM standard definition, are particles with lengths that range from 1 to 100 nanometers in two or three dimensions [8]. A nanoparticle is defined as the smallest unit that can still behave as a whole entity in terms of properties and transport. Nanoparticles are used in bioapplications such as therapeutics, antimicrobial agents, drug delivery agents, biosensors, imaging contrast agents, transfection vectors, and fluorescent labels. Nanoparticles are of great scientific interest as they bridge the gap between bulk materials and atomic or molecular structures. A bulk material has constant physical properties regardless of its size, but at the nanoscale this is often not the case. Several well-characterized bulk materials have been found to possess most interesting properties when studied in the nanoscale. There are many reasons for this including the fact that nanoparticles possess a very high aspect ratio. In the case of silver nanoparticles (AgNPs), this allows them to easily interact with other particles and increases their antibacterial efficiency. This effect is extremely robust, and as little as 1 g of AgNPs is known to impart antibacterial properties to hundreds of square meters of substrate material.

METALS AND METAL-OXIDE NANOPARTICLES

Metallic nanoparticles have possible applications in diverse areas such as electronics, cosmetics, coatings, packaging, and biotechnology. For example, nanoparticles can be induced to merge into a solid at relatively lower temperatures, often without melting, leading to improved and easy-to-create coatings for electronics applications (eg, capacitors). Typically, nanoparticles possess a wavelength below the critical wavelength of light. This renders them transparent, a property that makes them very useful for applications in cosmetics, coatings, and packaging. Metallic nanoparticles can be attached to single strands of DNA nondestructively. This opens up avenues for medical diagnostic applications. Nanoparticles can traverse through the vasculature and localize any target organ. This potentially can lead to novel therapeutic, imaging, and biomedical applications. Based on all of the above, the synthesis of metallic nanoparticles is an active area of academic and, more importantly, “application research” in nanotechnology.

Metal oxides play a very significant role in material science for instance fabrication of microelectronic circuits, sensors, piezoelectric devices, fuel cells, coatings for the passivation of surfaces against corrosion and as catalyst. Metal oxides have also been employed as sorbents for environmental pollutant. In the domain of nanotechnology, oxide nanoparticles can exhibit unique chemical properties owing to their limited size and high density of corner or edge surface sites. A number of physical and chemical preparative methods for accessing nanostructured oxides are on records . Among the metal oxides, nano ZnO exhibits wide band gap ($\sim 3.4\text{eV}$) and large exciton binding energy (60meV) and thus is considered most promising candidate for nanooptoelectronics, sensors, transistors, nanopiezoelectronics and UV-detection[9].

Various metal-oxide nanoparticles have been also prepared by Pulsed laser ablation in liquid media (PLAL). The concept of fabricating oxide using laser irradiation of metal targets in water was demonstrated in 1987, where iron and tantalum oxides were formed on target surfaces in water using a Q-switched ruby pulsed laser [10] and [11]. Although the preparation of various kinds of NPs by ablation of different targets in deionized water has been extensively studied in recent days, papers reporting the fabrication of metal oxide-based nanomaterials from metal targets by PLAL are still scarce compared with reports concerning the production of noble-metal nanoparticles.

Of the inorganic materials, metal oxides such as TiO₂, ZnO, MgO and CaO are of particular interest as they are not only stable under harsh process conditions but also generally regarded as safe materials to human beings and animals [12] and [13]. The use of nanoparticles of silver and zinc oxide has been seen as a viable solution to stop infectious diseases due to the antimicrobial properties of these nanoparticles. The intrinsic properties of a metal nanoparticle are mainly determined by size, shape, composition, crystallinity and morphology [14].

The solution phase synthesis of metal oxide nanoparticles typically involves the reaction of a metal salt with hydroxide ions[15]. The particle size is dependent on the kinetics of nucleation and growth from a supersaturated solution as well as processes such as coarsening, [16, 17] oriented attachment,[18-22] and aggregation. Synthesis of crystalline particles with diameters less than 10 nm is often performed in nonaqueous solvents where nucleation and growth are usually completed in a few minutes. Processes such as coarsening and oriented attachment occur at longer times and can have a large influence on particle size. The ability to separate nucleation and growth from supersaturation from processes such as coarsening and oriented attachment is important for controlling the particle size.

Classification of nanoparticles

Nanoparticles can be broadly grouped into two: namely organic and inorganic nanoparticles. Organic nanoparticles may include carbon nanoparticles (fullerenes) while some of the inorganic nanoparticles may include magnetic nanoparticles, noble metal nanoparticles (like gold and silver) and semiconductor nanoparticles (like titanium dioxide and zinc oxide).

There is a growing interest in inorganic nanoparticles as they provide superior material properties with functional versatility. Due to their size features and advantages over available chemical imaging drugs agents and drugs, inorganic nanoparticles have been examined as potential tools for medical imaging as well as for treating diseases. Inorganic nanomaterials have been widely used for cellular delivery due to their versatile features like wide availability, rich functionality, good biocompatibility, capability of targeted drug delivery and controlled release of drugs [23]. For example mesoporous silica when combined with molecular machines prove to be excellent imaging and drug releasing systems. Gold nanoparticles have been used extensively in imaging, as drug carriers and in thermo therapy of biological targets [24]. Inorganic

nanoparticles (such as metallic and semiconductor nanoparticles) exhibit intrinsic optical properties which may enhance the transparency of polymer- particle composites. For such reasons, inorganic nanoparticles have found special interest in studies devoted to optical properties in composites. For instance, size dependant colour of gold nanoparticles has been used to colour glass for centuries[25].

SYNTHESIS OF NANOPARTICLES

Nanoparticle having one or more dimensions of the order of 100nm or less- have attracted considerable attraction due to their unusual and fascinating properties, with various applications, over their bulk counterparts [26, 27]. Currently, a large number of physical, chemical, biological, and hybrid methods are available to synthesize different types of nanoparticles[28-31]. Though physical and chemical methods are more popular for nanoparticle synthesis, the use of toxic compounds limits their applications. The development of safe eco-friendly methods for biogenetic production is now of more interest due to simplicity of the procedures and versatility[32, 33].

Traditionally nanoparticles were produced only by physical and chemical methods. Some of the commonly used physical and chemical methods are ion sputtering, solvothermal synthesis, reduction and sol gel technique. Basically there are two approaches for nanoparticle synthesis namely the Bottom up approach and the Top down approach.

PHYSICAL AND CHEMICAL METHODS OF NANOPARTICLE SYNTHESIS

Some of the commonly used physical and chemical methods include:

- Sol-gel technique, which is a wet chemical technique used for the fabrication of metal oxides from a chemical solution which acts as a precursor for integrated network (gel) of discrete particles or polymers. The precursor sol can be either deposited on the substrate to form a film, cast into a suitable container with desired shape or used to synthesize powders.
- Solvothermal synthesis, which is a versatile low temperature route in which polar solvents under pressure and at temperatures above their boiling points are used. Under

solvothermal conditions, the solubility of reactants increases significantly, enabling reaction to take place at lower temperature.

- Chemical reduction, which is the reduction of an ionic salt in an appropriate medium in the presence of surfactant using reducing agents. Some of the commonly used reducing agents are sodium borohydride, hydrazine hydrate and sodium citrate.
- Laser ablation, which is the process of removing material from a solid surface by irradiating with a laser beam. At low laser flux, the material is heated by absorbed laser energy and evaporates or sublimates. At higher flux, the material is converted to plasma. The depth over which laser energy is absorbed and the amount of material removed by single laser pulse depends on the material's optical properties and the laser wavelength. Carbon nanotubes can be produced by this method.
- Inert gas condensation, where different metals are evaporated in separate crucibles inside an ultra-high vacuum chamber filled with helium or argon gas at typical pressure of few 100 pascals. As a result of inter atomic collisions with gas atoms in chamber, the evaporated metal atoms lose their kinetic energy and condense in the form of small crystals which accumulate on liquid nitrogen filled cold finger. E.g. gold nanoparticles have been synthesized from gold wires.

BIOSYNTHESIS OF NANOPARTICLES

The need for biosynthesis of nanoparticles rose as the physical and chemical processes were costly. So in the search of for cheaper pathways for nanoparticle synthesis, scientists used microorganisms and then plant extracts for synthesis. Nature has devised various processes for the synthesis of nano- and micro- length scaled inorganic materials which have contributed to the development of relatively new and largely unexplored area of research based on the biosynthesis of nanomaterials [34].

Biosynthesis of nanoparticles is a kind of bottom up approach where the main reaction occurring is reduction/oxidation. The microbial enzymes or the plant phytochemicals with anti oxidant or reducing properties are usually responsible for reduction of metal compounds into their respective nanoparticles.

The three main steps in the preparation of nanoparticles that should be evaluated from a green chemistry perspective are the choice of the solvent medium used for the synthesis, the choice of an environmentally benign reducing agent and the choice of a non toxic material for the stabilization of the nanoparticles. Most of the synthetic methods reported to date rely heavily on organic solvents. This is mainly due to the hydrophobicity of the capping agents used [35]. Synthesis using bio-organisms is compatible with the green chemistry principles: the bio-organism is (i) eco-friendly as are (ii) the reducing agent employed and (iii) the capping agent in the reaction [36]. Often chemical synthesis methods lead to the presence of some toxic chemical species adsorbed on the surface that may have adverse effects in medical applications [37]. This is not an issue when it comes to biosynthesized nanoparticles as they are eco friendly and biocompatible for pharmaceutical applications.

Use of organisms to synthesize nanoparticles

Biomimetics refers to applying biological principles for materials formation. One of the primary processes in biomimetics involves bioreduction. Initially bacteria were used to synthesize nanoparticles and this was later succeeded with the use of fungi, actinomycetes and more recently plants.

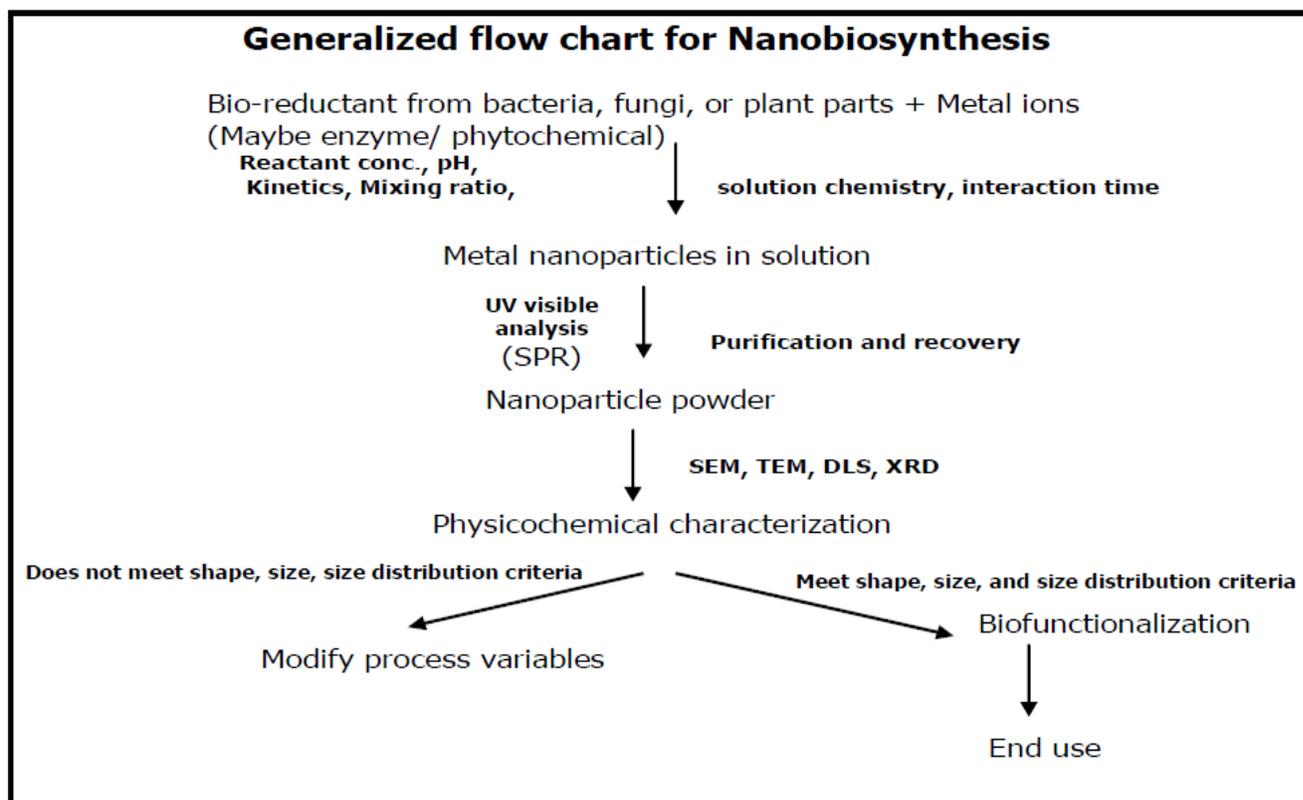


Fig. 1: Flowchart denoting the biosynthesis of nanoparticles

Use of plants to synthesize nanoparticles

The advantage of using plants for the synthesis of nanoparticles is that they are easily available, safe to handle and possess a broad variability of metabolites that may aid in reduction.

A number of plants are being currently investigated for their role in the synthesis of nanoparticles. Gold nanoparticles with a size range of 2- 20 nm have been synthesized using the live alfa alfa plants [38]. Nanoparticles of silver, nickel, cobalt, zinc and copper have also been synthesized inside the live plants of *Brassica juncea* (Indian mustard), *Medicago sativa* (Alfa alfa) and *Heliantus annus* (Sunflower). Certain plants are known to accumulate higher concentrations of metals compared to others and such plants are termed as hyperaccumulators. Of the plants investigated, *Brassica juncea* had better metal accumulating ability and later assimilating it as nanoparticles [39]. Recently much work has been done with regard to plant assisted reduction of metal nanoparticles and the respective role of phytochemicals. The main phytochemicals responsible have been identified as terpenoids, flavones, ketones, aldehydes,

amides and carboxylic acids in the light of IR spectroscopic studies. The main water soluble phytochemicals are flavones, organic acids and quinones which are responsible for immediate reduction. The phytochemicals present in *Bryophyllum sp.* (Xerophytes), *Cyprus sp.* (Mesophytes) and *Hydrilla sp.* (Hydrophytes) were studied for their role in the synthesis of silver nanoparticles. The Xerophytes were found to contain emodin, an anthraquinone which could undergo redial tautomerization leading to the formation of silver nanoparticles. The Mesophyte studied contained three types of benzoquinones, namely, cyperoquinone, dietchequinone and remirin. It was suggested that gentle warming followed by subsequent incubation resulted in the activation of quinones leading to particle size reduction. Catechol and protocatechaldehyde were reported in the hydrophyte studied along with other phytochemicals. It was reported that catechol under alkaline conditions gets transformed into protocatechaldehyde and finally into protocatecheucic acid. Both these processes liberated hydrogen and it was suggested that it played a role in the synthesis of the nanoparticles. The size of the nanoparticles synthesized using xerophytes, mesophytes and hydrophytes were in the range of 2- 5nm [40].

Recently gold nanoparticles have been synthesized using the extracts of *Magnolia kobus* and *Diopyros kaki* leaf extracts. The effect of temperature on nanoparticle formation was investigated and it was reported that polydisperse particles with a size range of 5- 300nm was obtained at lower temperature while a higher temperature supported the formation of smaller and spherical particles [41].

While fungi and bacteria require a comparatively longer incubation time for the reduction of metal ions, water soluble phytochemicals do it in a much lesser time. Therefore compared to bacteria and fungi, plants are better candidates for the synthesis of nanoparticles. Taking use of plant tissue culture techniques and downstream processing procedures, it is possible to synthesize metallic as well as oxide nanoparticles on an industrial scale once issues like the metabolic status of the plant etc. are properly addressed.

Abrus precatorius

Abrus precatorius L. is a member of the Papilionaceae family and known in various communities with different names. The names include cat's eye, bead tree, rosary pea and jeoquirity bean [42]. A climbing vine indigenous in India and Indonesia, leaves alternately compound, flowers arranged in clusters, violet or pink. The seed pod curls back when it opens

and reveals the seeds. The seeds are flat and truncate shaped, 1.5 . 2cm long, with attractive scarlet colour (Fig.2). They are highly poisonous. In leaves and roots sweet saponins are found, comparable with liquorice. These are known to be under the most toxic plant parts worldwide [43]. In the seeds the toxic principle is abrin, a mixture of at least five lectins, abrin A - D, and abrus-agglutinin. The abrins consist of two peptide chains connected by a disulfide bridge. Abrin A consists of an A-chain with N-glycosidase activity, which inhibits protein synthesis, and lectin-like B-chain responsible for binding with cell-surface receptors and penetrating of abrin-A molecule into the cell[44]. The toxicity of these abrins is variable, but they are the most potent toxins of the world, comparable with the botulinus toxin. *Abrus* agglutinin, is not so very toxic against cells, but it exhibits agglutination toward animal erythrocytes[45].

In the Ayurvedic medicine leaves of *Abrus precatorius* are laxative, expectorant and aphrodisiac medicines. Seeds are said to be purgative, emetic, tonic, antiphlogistic, aphrodisiac and antiophthalmic. For the indigenous people they are potent phytomedicines, many of them in mixtures with other plants. Their toxicity is underestimated. The plant has haemopoietic and immunomodulatory activities[46]. Regular and wider applications of *Abrus precatorius* leaf in the treatment of many diseases of human and animals in Nigeria have called for the need to investigate the biochemical effects of the plant in a biosystem, especially at the time when people are claiming the hepatoprotective property of the plant.

In this experiment we have taken the seed extract of these plant to synthesize zinc oxide (ZnO) nanoparticles and characterize them using different instruments.



Fig. 2. Plant *Abrus precatorius* showing leaves and flower.

ZnO Nanoparticles

Semiconductor nanoparticles are very important materials that have attracted attention of researchers because of their wide applications in material science, chemical and electric engineering during the past years. Nanoparticles have mainly two different excitations :i.exitonic transitions and ii.deep-trap transitions. Whilst excitonic transitions come from the band-edge(from conduction band to valance band), deep-trap transitions are caused by deep trap energy levels and the surface defects that appear especially at higher surface to volume ratios. This is a result of the physical properties of nanoparticles becoming size dependent when its radius becomes comparable to the Bohr radius of the bulk material. It is observed that the emission spectra from the excitonic level donot show any shift but if the emission spectra come from the deep trap level they show some considerable shifts upon changing the excitation wavelength. The emission spectra area direct function of the size of the nanoparticles and the optical properties of semiconductor nanoparticles are strongly dependent on the effective particle size. Surface to volume ratio is the most important point for the optical properties of the nanoparticles.As this ratio increased the effects of the deep-trap transitions, becomes inefficient [47, 48].

ZnO is a kind of wide band gap (3.37 eV) semiconductor with large exciton binding energy (60 meV) [49]. ZnO is a biofriendly oxide semiconductor and an inexpensive luminescent material. It has attracted intensive research efforts for its unique properties and versatile applications in antireflection coatings, transparent electrodes in solar cells, ultraviolet (UV) light emitters, diode lasers, varistors, piezoelectric devices, spin-electronics, surface acoustic wave propagator [50, 51], antibacterial agent [52], photonic material [53] and for gas sensing [54]. In general, ZnO is considered “generally recognized as safe” (GRAS) [55] but ZnO nanoparticle system may be toxic.

Among all the inorganic semiconducting nanoparticles, zinc oxide nanoparticles have attracted increasing attention because ZnO nanoparticles can be easily synthesized and ZnO is a “green” material that is biocompatible, biodegradable, and nontoxic for medical applications and environmental science [12]. Recently, there are several physical or chemical synthetic methods of preparing ZnO, such as thermal evaporation [56], pulsed laser deposition (PLD) [57], ion implantation [58], reactive electron beam evaporation [59], thermal decomposition [60] and sol-gel technique [61]. Recently, great effort has been made to the synthesis of size-controlled ZnO₂ nanoparticles in order to explore their potentials.

PROPERTIES OF ZnO:-

In this section crystal structures, inclusive of lattice parameters, electronic band structures, mechanical properties, inclusive of elastic constants and piezoelectric constants, lattice dynamics and vibrational processes, thermal properties, electrical properties, and low-field and high-field carrier transports are treated.

❖ STRUCTURE OF ZINC OXIDE (ZnO)

Most of the group-II-VI binary compound semiconductors crystallize in either cubic zinc-blende or hexagonal wurtzite structure where each anion is surrounded by four cations at the corners of a tetrahedron, and vice versa. This tetrahedral coordination is typical of *sp*³ covalent bonding, but these materials also have a substantial ionic character. ZnO is a II-VI compound semiconductor whose ionicity resides at the borderline between covalent and ionic semiconductor. The crystal structures shared by ZnO are wurtzite *B*₄, zinc blende *B*₃, and rocksalt *B*₁, as schematically shown in Fig. 3. At ambient conditions, the thermodynamically

stable phase is wurtzite. The zinc blende ZnO structure can be stabilized only by growth on cubic substrates, and the rocksalt NaCl structure may be obtained at relatively high pressures.

The zinc blende form can be stabilized by growing ZnO on substrates with cubic lattice structure. In both cases, the zinc and oxide centers are tetrahedral, the most characteristic geometry for Zn(II). In addition to the wurtzite and zinc blende polymorphs, ZnO can be crystallized in the rock salt motif at relatively high pressures about 10 GPa[62]. Hexagonal and zinc blende polymorphs have no inversion symmetry (reflection of a crystal relative to any given point does not transform it into itself). This and other lattice symmetry properties result in piezoelectricity of the hexagonal and zincblende ZnO, and pyroelectricity of hexagonal ZnO.

The hexagonal structure has a point group 6 mm (Hermann-Mauguin notation) or C_{6v} (Schoenflies notation), and the space group is $P6_3mc$ or C_{6v}^4 . The lattice constants are $a = 3.25 \text{ \AA}$ and $c = 5.2 \text{ \AA}$; their ratio $c/a \sim 1.60$ is close to the ideal value for hexagonal cell $c/a = 1.633$. As in most group II-VI materials, the bonding in ZnO is largely ionic ($\text{Zn}^{2+}\text{O}^{2-}$) with the corresponding radii of 0.074 nm for Zn^{2+} and 0.140 nm for O^{2-} . This property accounts for the preferential formation of wurtzite rather than zinc blende structure as well as the strong piezoelectricity of ZnO. Because of the polar Zn-O bonds, zinc and oxygen planes are electrically charged. To maintain electrical neutrality, those planes reconstruct at atomic level in most relative materials, but not in ZnO its surfaces are atomically flat, stable and exhibit no reconstruction [63].

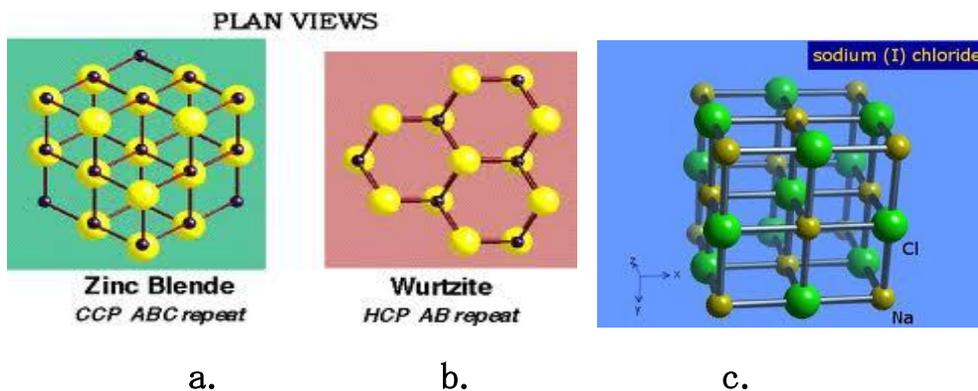


Fig. 3 Stick and ball representation of ZnO crystal structures: a) hexagonal wurtzite *B4*. b) cubic zinc blende *B3*, and c) cubic rocksalt *B1*,

❖ LATTICE PARAMETERS

The lattice parameters of a semiconductor usually depend on the following factors: i. free-electron concentration acting via deformation potential of a conduction-band minimum occupied by these electrons, ii. concentration of foreign atoms and defects and their difference of ionic radii with respect to the substituted matrix ion, iii. external strains for example, those induced by substrate, and iv. temperature. The lattice parameters of any crystalline material are commonly and most accurately measured by high resolution x-ray diffraction HRXRD by using the Bond method for a set of symmetrical and asymmetrical reflection [64].

For the wurtzite ZnO, lattice constants at room temperature determined by various experimental measurements and theoretical calculations are in good agreement. The lattice constants mostly range from 3.2475 to 3.2501 Å for the a parameter and from 5.2042 to 5.2075 Å for the c parameter. The c/a ratio and u parameter vary in a slightly wider range, from 1.593 to 1.6035 and from 0.383 to 0.3856, respectively. The deviation from that of the ideal wurtzite crystal is probably due to lattice stability and ionicity. It has been reported that free charge is the dominant factor responsible for expanding the lattice proportional to the deformation potential of the conduction-band minimum and inversely proportional to the carrier density and bulk modulus. The point defects such as zinc antisites, oxygen vacancies, and extended defects, such as threading dislocations, also increase the lattice constant, albeit to a lesser extent in the heteroepitaxial layers.

For the zinc-blende polytype of ZnO, the calculated lattice constants based on a modern *ab initio* technique are predicted to be 4.60 and 4.619 Å. A high-pressure phase transition from the wurtzite to the rocksalt structure decreases the lattice constant down to the range of 4.271–4.294 Å [65].

❖ MECHANICAL PROPERTIES

The mechanical properties of materials involve various concepts such as hardness, stiffness, and piezoelectric constants, Young's and bulk moduli, and yield strength. Although the wurtzite ZnO crystal is acoustically anisotropic, there is only a very small difference between the shear sound velocities v_{TA1} and v_{TA2} propagating along the $\{001\}$ and (100) directions, respectively (v_{TA2}/v_{TA1}) = 0.98.

Piezoelectricity is the electric charge that accumulates in certain solid materials in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure. The piezoelectric effect is understood as the linear electromechanical interaction between the mechanical and the electrical state in crystalline materials with no inversion symmetry. The piezoelectric effect is a reversible process in that materials exhibiting the direct piezoelectric effect (the internal generation of electrical charge resulting from an applied mechanical force) also exhibit the reverse piezoelectric effect (the internal generation of a mechanical strain resulting from an applied electrical field). The inverse piezoelectric effect is used in production of ultrasonic sound waves. Among the tetrahedrally bonded semiconductors, it has been stated that ZnO has the highest piezoelectric tensor. This property makes it a technologically important material for many applications, which require a large electromechanical coupling. The piezoelectric tensor has three independent components in hexagonal wurtzite phase and one in the cubic zinc-blende phase, which characterize the full piezoelectric tensors of such crystals. Two of these components in wurtzite phase measure the polarization induced along the c axis, at zero electric field, by a uniform strain either along the c axis or in the basal plane [66].

❖ ELECTRONIC PROPERTIES

ZnO has a relatively large direct band gap of ~ 3.3 eV at room temperature; therefore, pure ZnO is colorless and transparent. Advantages associated with a large band gap include higher breakdown voltages, ability to sustain large electric fields, lower electronic noise, and high temperature and high-power operation. The bandgap of ZnO can further be tuned from $\sim 3\text{--}4$ eV by its alloying with magnesium oxide or cadmium oxide.

Most ZnO has n -type character, even in the absence of intentional doping. Native defects such as oxygen vacancies or zinc interstitials are often assumed to be the origin of this, but the subject remains controversial. An alternative explanation has been proposed, based on theoretical calculations, that unintentional substitutional hydrogen impurities are responsible. Controllable n -type doping is easily achieved by substituting Zn with group-III elements Al, Ga, In or by substituting oxygen with group-VII elements chlorine or iodine. Reliable p -type doping of ZnO remains difficult. This problem originates from low solubility of p -type dopants and their compensation by abundant n -type impurities, and it is pertinent not only to ZnO, but also to

similar compounds GaN and ZnSe. Measurement of p-type in "intrinsically" n-type material is also not easy because inhomogeneity results in spurious signals.

Current absence of p-type ZnO does limit its electronic and optoelectronic applications which usually require junctions of n-type and p-type material. Known p-type dopants include group-I elements Li, Na, K; group-V elements N, P and As; as well as copper and silver. However, many of these form deep acceptors and do not produce significant p-type conduction at room temperature. Electron mobility of ZnO strongly varies with temperature and has a maximum of $\sim 2000 \text{ cm}^2/(\text{V}\cdot\text{s})$ at ~ 80 Kelvin.[21] Data on hole mobility are scarce with values in the range 5-30 $\text{cm}^2/(\text{V}\cdot\text{s})$.

❖ OPTICAL PROPERTIES

ZnO is a wide band gap semiconductor that displays luminescent properties in the near ultra violet and the visible regions. The emission properties of ZnO nanoparticles in the visible region widely depend on their synthetic method as they are attributable to surface defects. Recently, we have developed a novel organometallic synthetic method for the preparation at room temperature of crystalline ZnO nanoparticles of controlled size and shape. The studies on the emission properties of nanocrystalline ZnO nanoparticles and nanorods was prepared following this organometallic synthetic method. They observed a clear influence of the shape of the particles and of the ligands on the luminescence properties in the visible domain. They observed two different emissions at 440 nm and at 580 nm that are associate with the presence of surface defects on the particles. The first one corresponds to the well known yellow emission located at 580 nm with a lifetime of 1850 ns for 4.0 nm size particles. The second emission at 440 nm is observed when amine ligands are present. Based on the optical measurements, they have proposed mechanism at the origin of the two emissions. They also observed that the modification of the relative intensity between the two emissions is related to a specific location of the amine ligands on the surface of the particles.

ZnO NANOSTRUCTURES

One-dimensional semiconductor nanowires and nanorods have attracted increasing attention due to their physical properties arising from quantum confinement such as electronic quantum

transport and enhanced radiative recombination of carriers. Nanowires have promising potentials in extensive applications and are the fundamental building blocks for fabricating short-wavelength nanolasers, field-effect transistors, ultrasensitive nanosized gas sensors, nanoresonators, transducers, actuators, nanocantilevers, and field emitters(Fes). These nanostructures are the ideal systems for studying transport mechanisms in one-dimensional (1D) systems, which are of benefit not only for understanding the fundamental phenomena in low-dimensional systems but also for developing new generation nanodevices with high performance. Many nanowires made of materials such as Si, C, InP, GaAs, CdS, SnO₂, GaN, ZnO, and In₂O₃ have been fabricated for different applications using mostly a catalystassisted vapor-liquid-solid (VLS) growth method (solid vapor process). Among these materials ZnO is considered to be the most prospective one due to its large exciton binding energy (60 meV), high electromechanical coupling constant, and resistivity to harsh environment. Therefore, 1D ZnO structures stimulated so much attention, and a large number of publications have appeared lately reporting nanostructures of various shapes such as nanowires , nanobelts, nanorings, nanotubes, nanodonuts , nanopropellers ,etc. grown by different methods [65].

APPLICATIONS OF ZnO NPs

At present, the most widely revealed application for ZnO is an ITO replacement for displays and photovoltaic panels, where ZnO could lower costs of transparent conductors. In addition to its conductive nature, it also can be used as a semiconductor for making inexpensive transistors for disposable electronics or even low-cost LEDs. ZnO is also finding applications in thin-film batteries, and ZnO's ability to be engineered into interesting nanostructures hints at new applications down the road. ZnO already is being tapped in spintronics.

Due to their excellent optical and electrical properties, ZnO nanoparticles have become predominant semiconductor materials for nanoscale devices, such as nano-generators, gas sensors, highly efficient solarcells, field-emission transistors , ultra violet photodetectors , and biomedical systems ZnO is attracting considerable attention for its possible application to UV light emitters, spin functional devices, gas sensors, transparent electronics and surface acoustic wave devices [67].

Cytotoxicity of nanoparticles

The special physicochemical properties of nanoparticles cause potential risk to human health [68]. So considerable effort has been made to identify the potential toxicity of nanoparticles to cells and organism. Exposure of cells to certain type nanoparticles can induce cytotoxicity and many effects like oxidative injury, inflammation, fibrosis, and release of pro-inflammatory mediators. The pathophysiological responses have also been found like generation of ROS (Reactive oxygen species) in cells when cells are exposed to nanoparticles. This ROS generation is the initiating factor for toxicity of nanoparticles exposed to cells. Another initiating factor was lysosomal destabilization. loss of mitochondrial membrane integrity cause cell death. Nanoparticles cause toxicity because: a) nanostructures have electronic, optical and magnetic properties that tells about the physical dimensions and breakage in the nanostructures can lead to a unique toxic effect that is unpredictable. b) The surfaces of nanostructures are involved in many catalytic and oxidative reaction. These reactions may induce cytotoxicity. cytotoxicity can be greater in the nanomaterial than a bulk material because surface area to volume ratio for nanoparticle is more. c) some nanostructures contain metals or compound with toxicity when breakdown can elicit toxic responses to the components themselves [69].

Common assumption about the nanostructures is that smaller size of nanostructures can easily enter into tissues, cells, organelles and functional biomolecular structures, as the actual size of an engineered nanostructures is similar to many biological molecules and structures. The entry of the nanostructures into biological systems can cause damage, which can cause harm to human health. Nanostructures can enter biological system via six principle routes: intra venous, dermal, subcutaneous, inhalation, intraperitoneal, and oral. After entry absorption takes place where nanostructures first interact with biological component like proteins, cells. Then they are distributed to various organs in body and may be structurally same, may be modified or metabolized [67].

OBJECTIVES

- ◎ **Synthesis of Zinc Oxide (ZnO) nanoparticle**
- ◎ **Physical characterization using SEM, UV-visible spectroscopy, FTIR, XRD, Particle Size Analysis (DLS) and Zeta Potential measureme**

MATERIALS AND METHOD

1) Preparation of *Abrus precatorius* seed extract

Seeds shown in fig.4 were grinded after removal of outer coating. Then the powdered form of seed was used to synthesize ZnO nanoparticles.



Fig.4 *Abrus precatorius* seeds

1) Synthesis of Zinc Oxide Nanoparticles:

Four concentration ratios of seed extract and metal ions were prepared (30:1, 60:1, 120:1 & 240:1) by increasing the concentration of seed extract in deionized water. 1% plant extract solution was prepared with deionized water. The prepared solution was set for incubation for 30 min. at 37° C. then the solution was set for centrifugation for 30 mins. at 25° C in 10000 rpm and the supernatant was collected. The supernatant was then filtered and 10.97 mg was added in the solution.

2) Characterization of Silver Nanoparticles:

UV-Visible Analysis:

The optical property of zinc oxide was determined by the result of UV-Vis spectrophotometer. After the addition of zinc acetate to all the ratio i.e 240:1, 120:1, 60:1, 30:1, the spectra was taken in time interval up to 4hrs between 300 nm to 500 nm. Then the spectra was taken after 24 hrs. of zinc acetate addition.

FTIR analysis:

Supernatant of ratio 30:1 and 120:1 that we collected was dried at 75° C and the dried powder was taken for FTIR analysis. FTIR was obtained in the range 4000–400 Cm⁻¹ using KBR pellet method.

SEM Analysis:

After 24Hrs. of the addition of zinc acetate the SEM slide was prepared by making a smear of the solution on a slide. Then the slide was set for SEM analysis after coating the slide with platinum and the SEM image was taken.

DLS & Zeta-Potential Analysis:

The supernatant of ratio 60:1 was filtered and then sonicated for 5 minutes. The the solution was centrifuged for 15 min.at 25° C with 5000 rpm and the supernatant was collected. Then the supernatant was diluted for 4 to 5 times and then set for DLS and Zeta-Potential analysis.

XRD Analysis:

ZnO nanoparticles were examined by X-ray diffractometer. The powdered metal was stucked in the cubes of XRD and then the result was taken in the XRD equipment.

RESULTS AND DISCUSSION:

UV-visible spectrophotometer

It refers to absorption spectroscopy or reflectance spectroscopy in the ultraviolet-visible spectral region. This means it uses light in the visible and adjacent ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. In this region of the electromagnetic spectrum, molecules undergo electronic transitions. It is based on the principle that molecules containing π -electrons or non-bonding electrons (n-electrons) can absorb the energy in the form of ultraviolet or visible light to excite these electrons to higher anti-bonding molecular orbitals. The more easily excited the electrons (i.e. lower energy gap between the HOMO and the LUMO), the longer the wavelength of light it can absorb.

The figures showing the graph of uv-visible spectrophotometer for four ratios are as follows (Fig5-8):

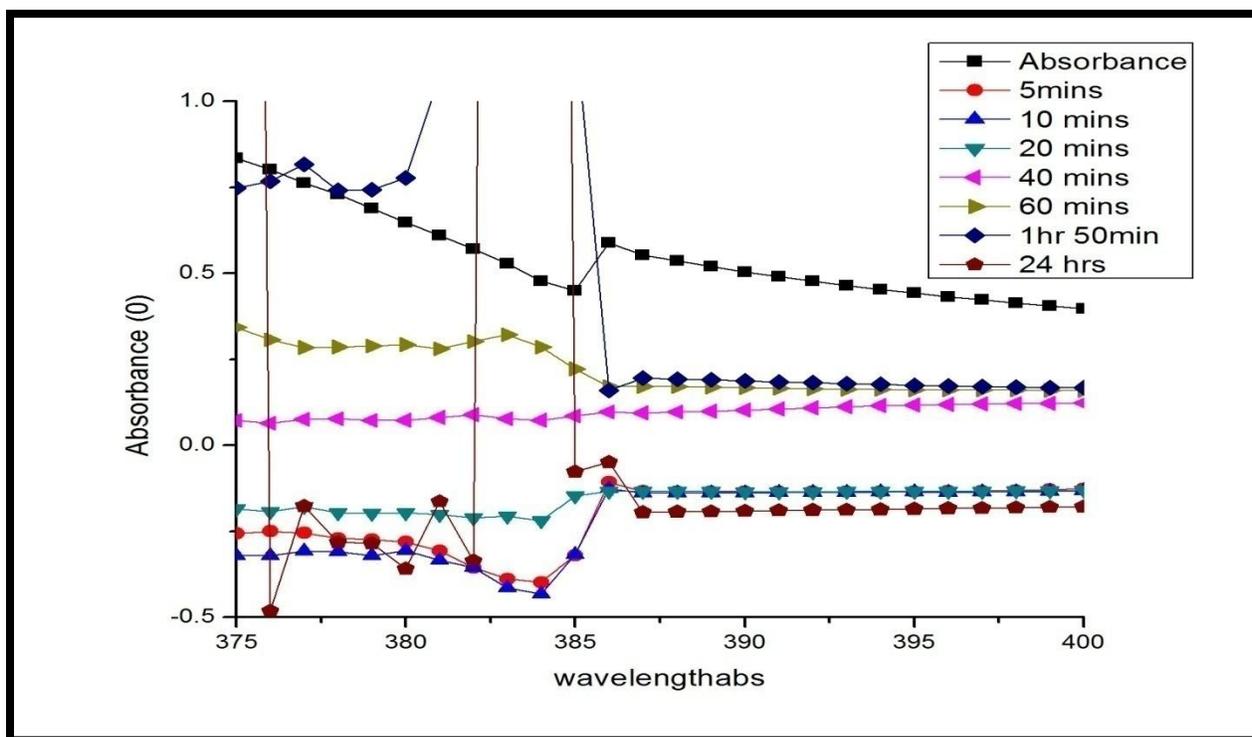


Figure 5: UV image of ZnO NPs 30:1 in different time interval

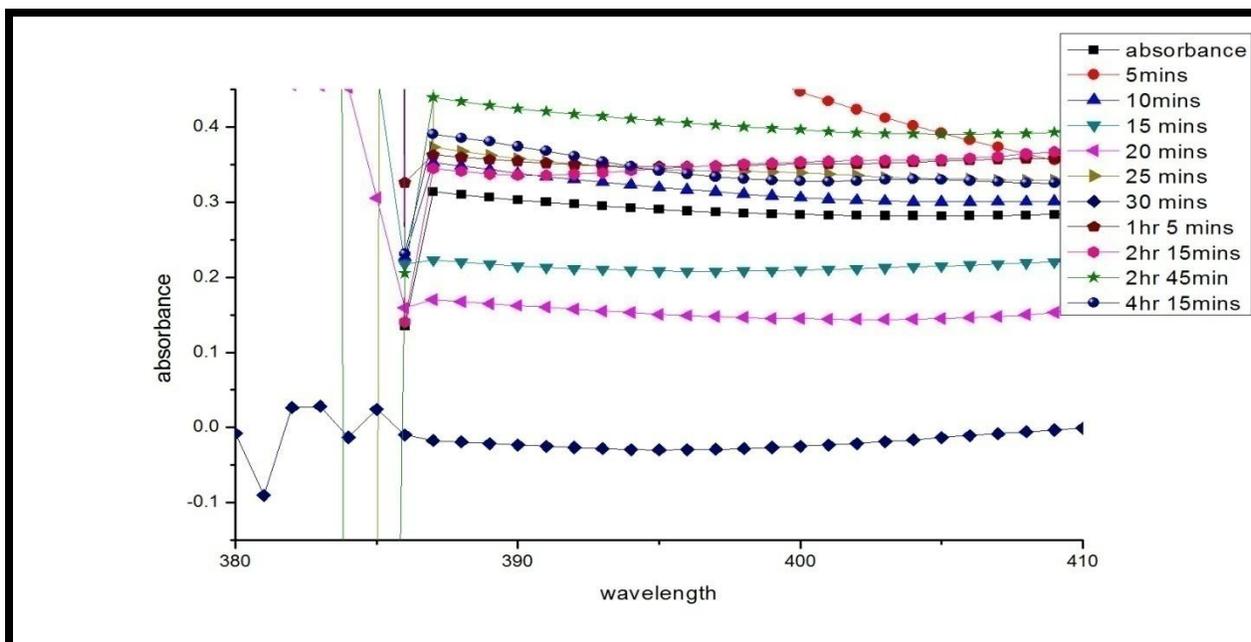


Figure 6: UV image of ZnO NPs 60:1 in different time interval

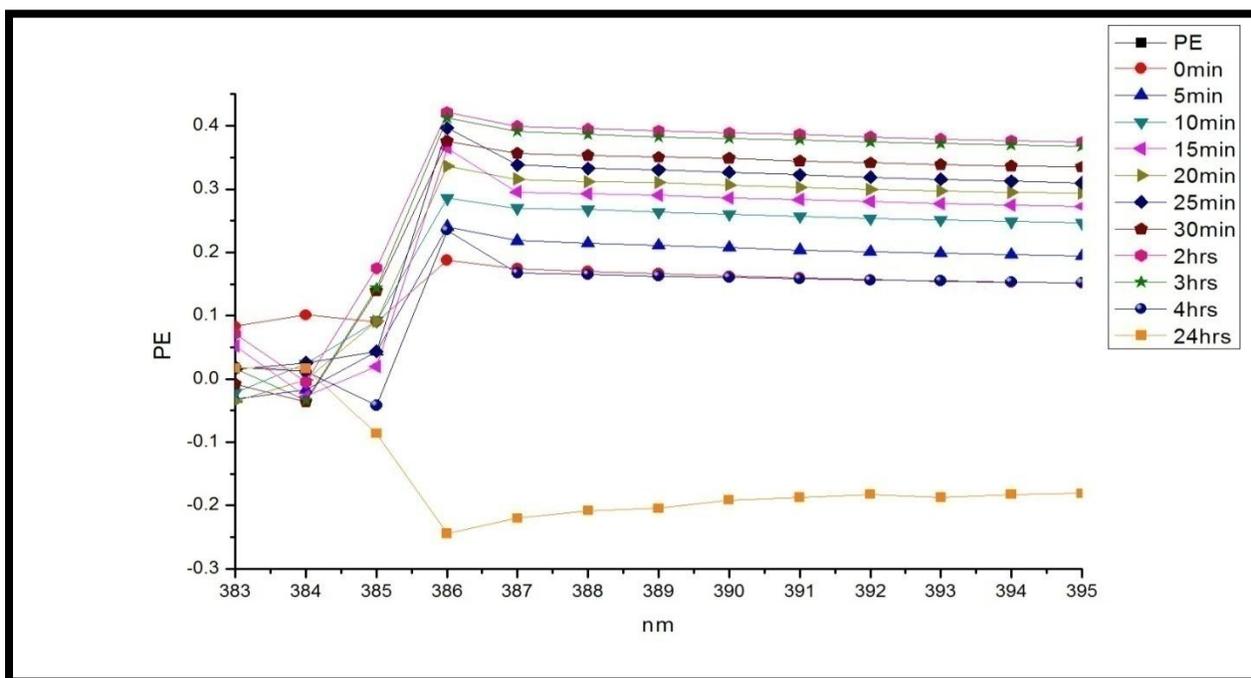


Figure 7: UV image of ZnO NPs 120:1 in different time interval

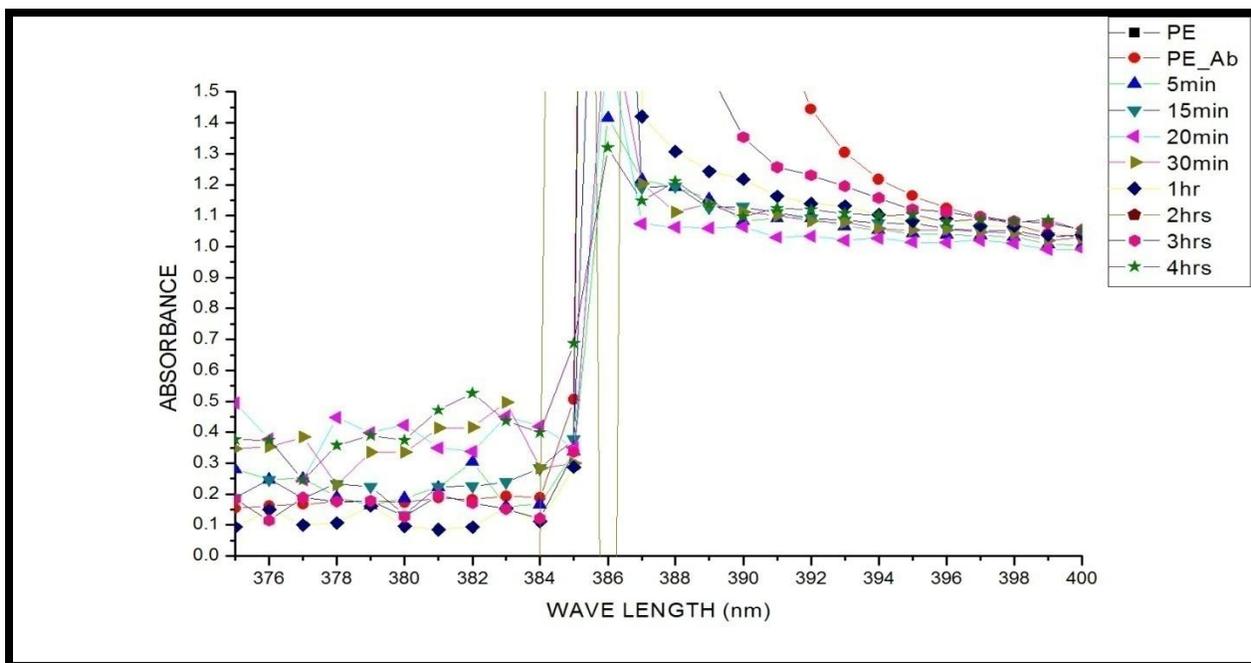


Figure 8: UV image of ZnO NPs 240:1 in different time interval

The colour change i.e light white to dark white colour was observed in the UV- vis spectrophotometer is due to the Plasmon resonance phenomenon which is the collection of oscillation of electrons. The reduction zinc acetate to zinc oxide is monitored by UV- vis spectrum. The band was observed around 386 – 450 nm which was identified as “surface Plasmon resonance band” and this band is ascribed to excitation of valence electrons of ZnO arranged in the nanoparticles (nanocrystal/ nanosphere). The shape of the band was symmetrical, suggesting uniform scattering of spherical shape nanoparticles.

SEM RESULT

It is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with electrons in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer.

The SEM images of four different ratios are as follows (Fig.9 -12).

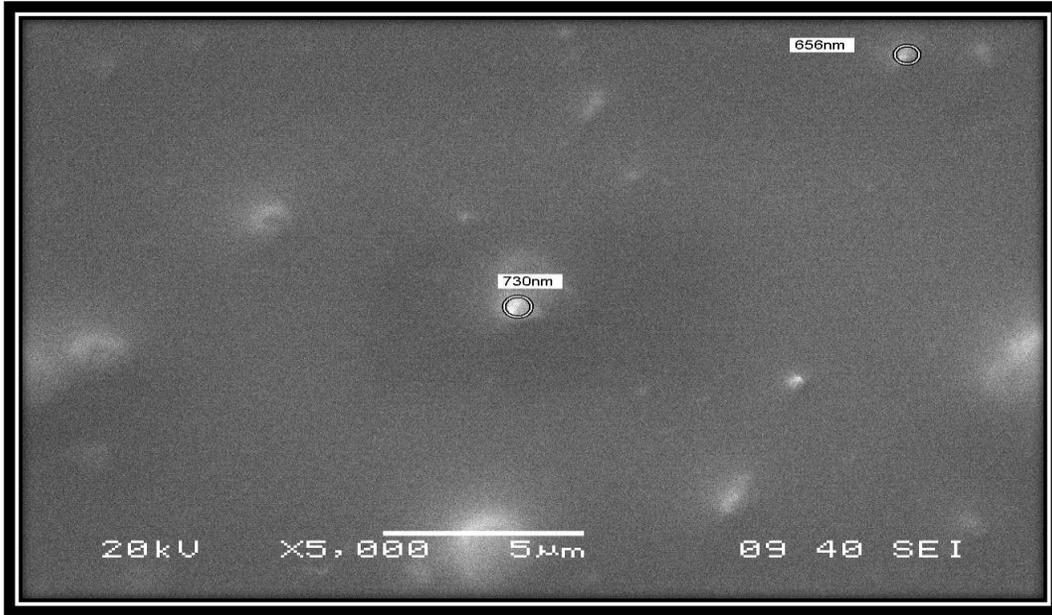


Fig. 9: SEM image of ZnO NPs synthesized from Abrus with 30:1 ratio



Fig. 10: SEM image of ZnO NPs synthesized from Abrus with 60:1 ratio

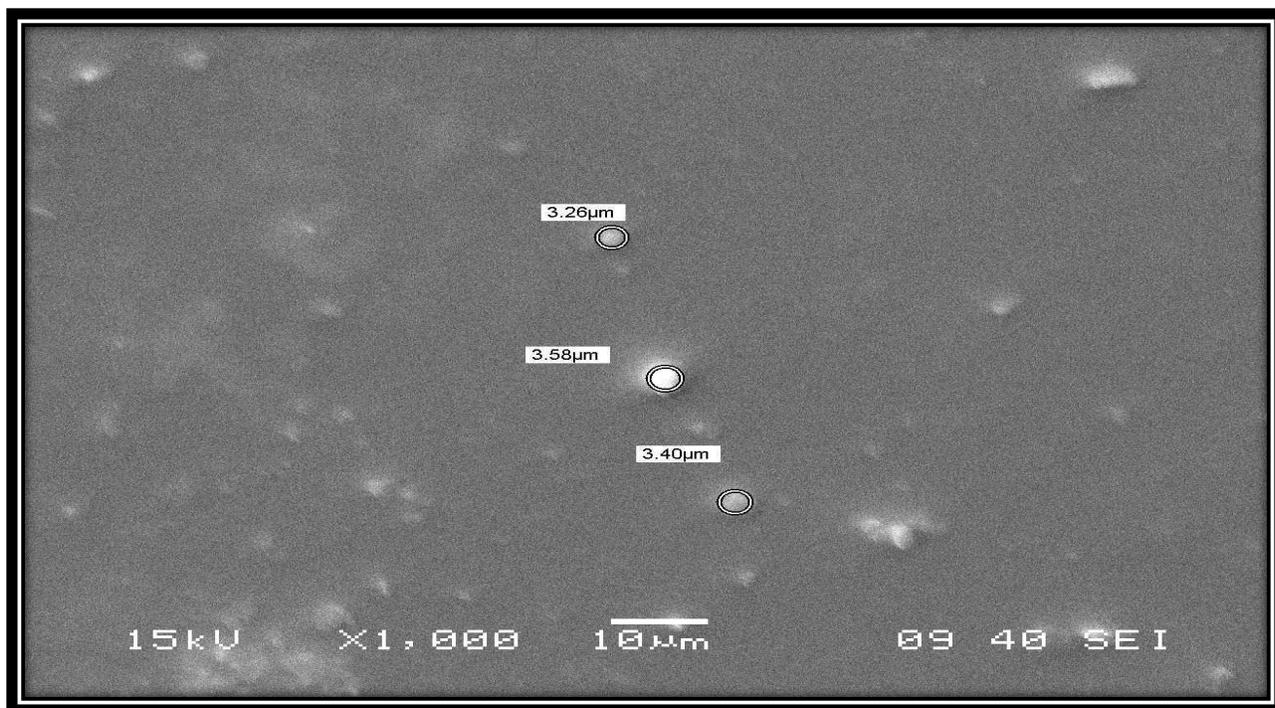


Fig. 11: SEM image of ZnO NPs synthesized from Abrus with 120:1 ratio

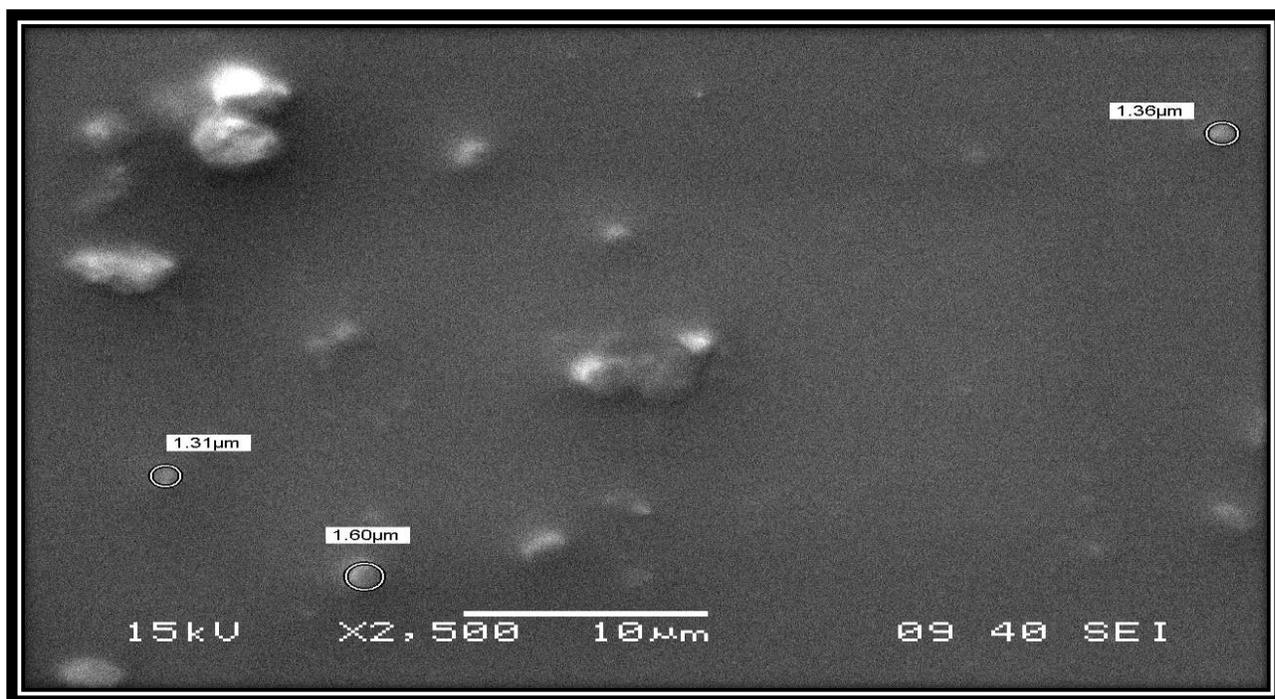


Fig. 12: SEM image of ZnO NPs synthesized from Abrus with 240:1 ratio

SEM provided further insight into the morphology and size details of the ZnO nanoparticle. The size of the particles was from nano to micron range and morphology of particles was nearly spherical in all ratio except in 240:1 ratio. In 240:1 ratio different morphology was observed i.e spherical , rod shape particles was observed , this is because in this ratio the population of seed extract was more. The size of the prepared nanoparticles was more than the size of nanoparticle i.e.; between 1-100 nm. This was because the proteins were bound to the surface of the nanoparticles. As the ratio differs size also differs, this is because of the concentration varies.

FTIR RESULT

This FTIR gives information on the vibrational and rotational modes of motion of a molecule and hence an important technique for identification and characterisation of a substance. The Infrared spectrum of an organic compound provides a unique fingerprint, which is readily distinguished from the absorption patterns of all other compounds; only optical isomers absorb in exactly the same way. Hence FTIR is an important technique for identification and characterization of a substance.

The results of FTIR are as shown in Fig.13 -14

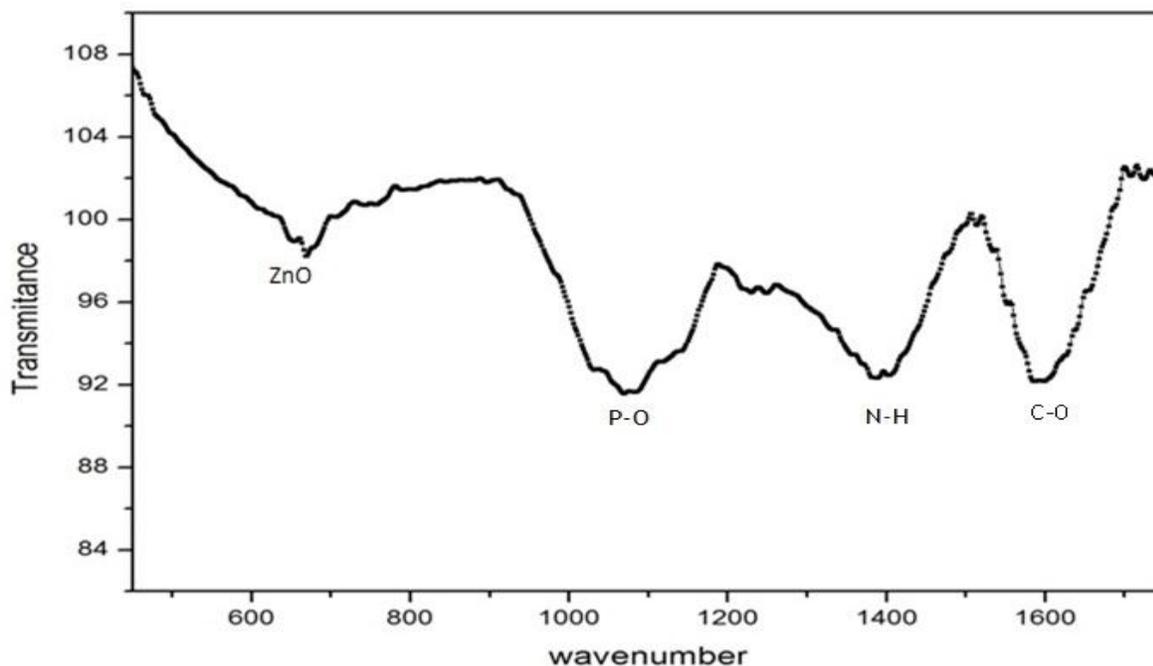


Fig.13 FTIR Graph of ZnO NPs synthesized from Abrus with ratio 30:1

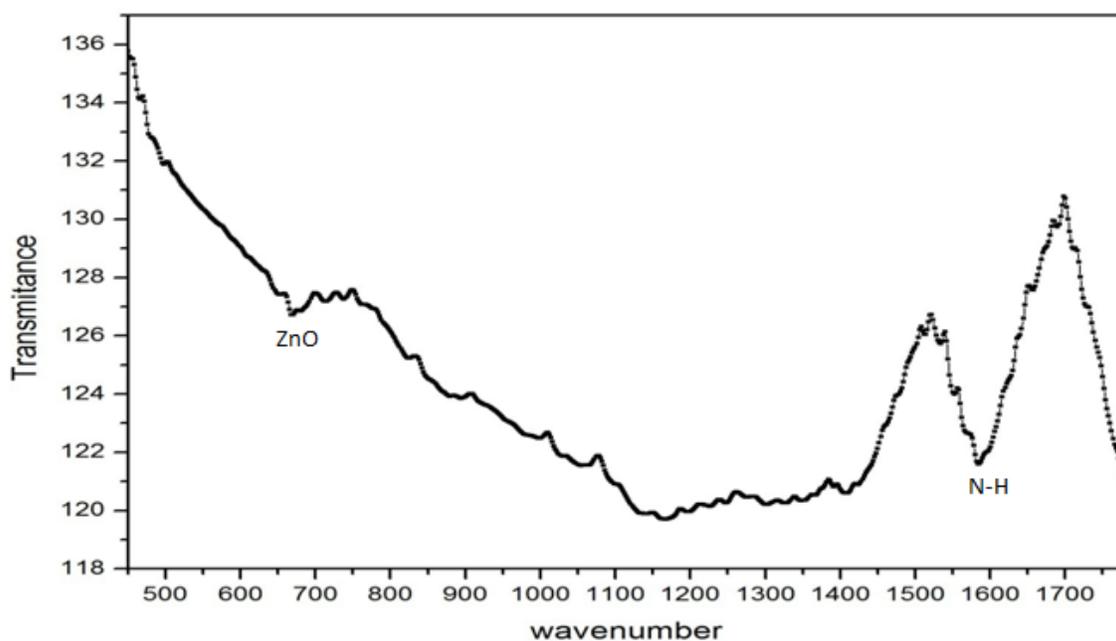


Fig.14 FTIR Graph of ZnO NPs synthesized from Abrus with ratio 120:1

Possible biomolecules responsible for the reduction of ZnO and capping agent of bio-reduced ZnO NPs through particular bond vibrations peaks coming at defined wavenumbers was identified. The peak found around 1450-1500 cm^{-1} showed the bond stretch for N-H. Whereas the stretch for ZnO nanoparticles were found around 400-800 cm^{-1} . Therefore the synthesized nanoparticles were surrounded by proteins and metabolites such as terpenoids having functional groups. From the analysis of FTIR studies we confirmed that the carbonyl groups from the amino acid residues and proteins has the stronger ability to bind metal indicating that the proteins could possibly form the metal nanoparticles (i.e.; capping of silver nanoparticles) to prevent agglomeration and thereby stabilize the medium. This suggests that the biological molecules could possibly perform dual functions of formation and stabilization of ZnO nanoparticles in the aqueous medium. Carbonyl groups proved that flavanones or terpenoids adsorbed on the surface of metal nanoparticles. Flavanones or terpenoids could be adsorbed on the surface of metal nanoparticles, possibly by interaction through carbonyl groups or π -electrons in the absence of other strong ligating agents in sufficient concentration. The presence of reducing sugars in the solution could be responsible for the reduction of metal ions and formation of the corresponding metal nanoparticles. It is also possible that the terpenoids play a role in reduction of metal ions by oxidation of aldehydic groups in the molecules to carboxylic acids.

DLS RESULT

It is also known as photon correlation spectroscopy or quasi-elastic light scattering. It is a technique in physics that can be used to determine the size distribution profile of small particles in suspension or polymers in solution. It can also be used to probe the behavior of complex fluids such as concentrated polymer solutions.

It is used to characterize size of various particles including proteins, polymers, micelles, carbohydrates, and nanoparticles. If the system is monodisperse, the mean effective diameter of the particles can be determined. This measurement depends on the size of the particle core, the size of surface structures, particle concentration, and the type of ions in the medium.

Since it essentially measures fluctuations in scattered light intensity due to diffusing particles, the diffusion coefficient of the particles can be determined. It is used to study stability of the particles. It also show whether the particles aggregate over time by seeing whether the hydrodynamic radius of the particle increases. If particles aggregate, there will be a larger population of particles with a larger radius.

Result of DLS of the ratio 60:1 (fig.15)

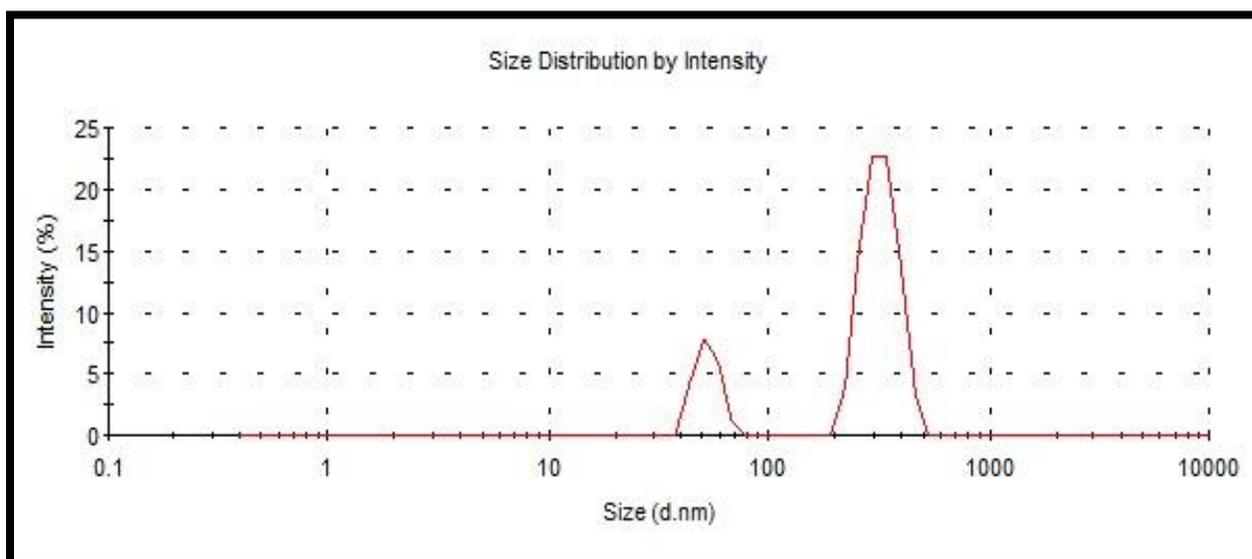


Fig. 15: DLS image of ZnO NPs 60:1

DLS result showed that particles were polydispersed means different size of particles were formed i.e the population of particle size 500nm was more than 90nm particles.

ZETA POTENTIAL RESULT

Zeta potential is the electric potential in the interfacial double layer (DL) at the location of the slipping plane versus a point in the bulk fluid away from the interface. In other words, it is the potential difference between the dispersion medium and the stationary layer of fluid attached to the dispersed particle. A value of 25 mV (positive or negative) can be taken as the arbitrary value that separates low-charged surfaces from highly-charged surfaces. The significance of zeta potential is that its value can be related to the stability of colloidal dispersions (e.g., a multivitamin syrup). The zeta potential indicates the degree of repulsion between adjacent, similarly charged particles (the vitamins) in a dispersion. For molecules and particles that are small enough, a high zeta potential will confer stability, i.e., the solution or dispersion will resist aggregation. When the potential is low, attraction exceeds repulsion and the dispersion will break and flocculate. Zeta potential (Surface potential) has direct relation with the stability of a form/structure as mentioned in table 1.

Table.1. Zeta potential (Surface potential) has direct relation with the stability of a form/structure as mentioned below:

Zeta potential [mV]	Stability behavior of the colloid
From 0 to ± 5	Rapid coagulation or flocculation
From ± 10 to ± 30	Incipient instability
From ± 30 to ± 40	Moderate stability
From ± 40 to ± 60	Good stability
More than ± 61	Excellent stability

Result of zeta potential of ratio 60:1 (fig. 16).

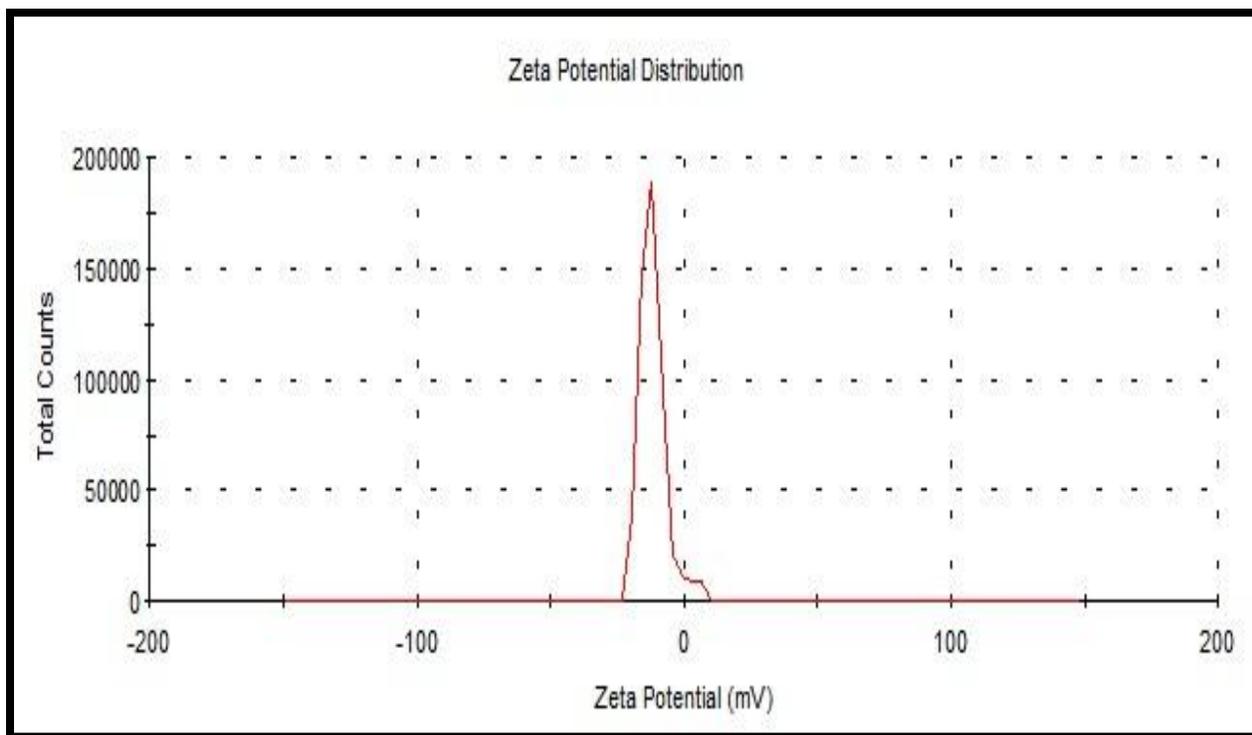


Fig.16: Zeta analysis image of ZnO NPs 60:1

The result of zeta potential showed that surface potential of NPs was found to be 12 mV i.e, incipient instability.

XRD

X-ray diffraction is a versatile, non-destructive analytical method for identification and quantitative determination of various crystalline forms, known as ‘phases’ of compound present in powder and solid samples. Diffraction occurs as waves interact with a regular structure whose repeat distance is about the same as the wavelength. For example, light can be diffracted by a grating having scribed lines spaced on the order of a few thousand angstroms, about the wavelength of light. It happens that X-rays have wavelengths on the order of a few angstroms, the same as typical inter-atomic distances in crystalline solids. That means X-rays can be diffracted from minerals which, by definition, are crystalline and have regularly repeating atomic structures. When certain geometric requirements are met, X-rays scattered from a crystalline solid can constructively interfere, producing a diffracted beam. In 1912, W. L. Bragg recognized a predictable relationship among several factors.

1. The distance between similar atomic planes in a mineral (the interatomic spacing) which we

call the d-spacing and measure in angstroms.

2. The angle of diffraction which we call the theta angle and measure in degrees. For practical reasons the diffractometer measures an angle twice that of the theta angle. Not surprisingly, we call the measured angle '2-theta'.

3. The wavelength of the incident X-radiation, symbolized by the Greek letter lambda and, in our case, equal to 1.54 angstroms.

$$n\lambda=2d\sin\theta ,$$

where, λ - wavelength of X-ray

d-interplaner spacing,

θ -diffraction angle

n-0,1,2,3....

X-ray diffraction is widely used for X-ray crystallography.

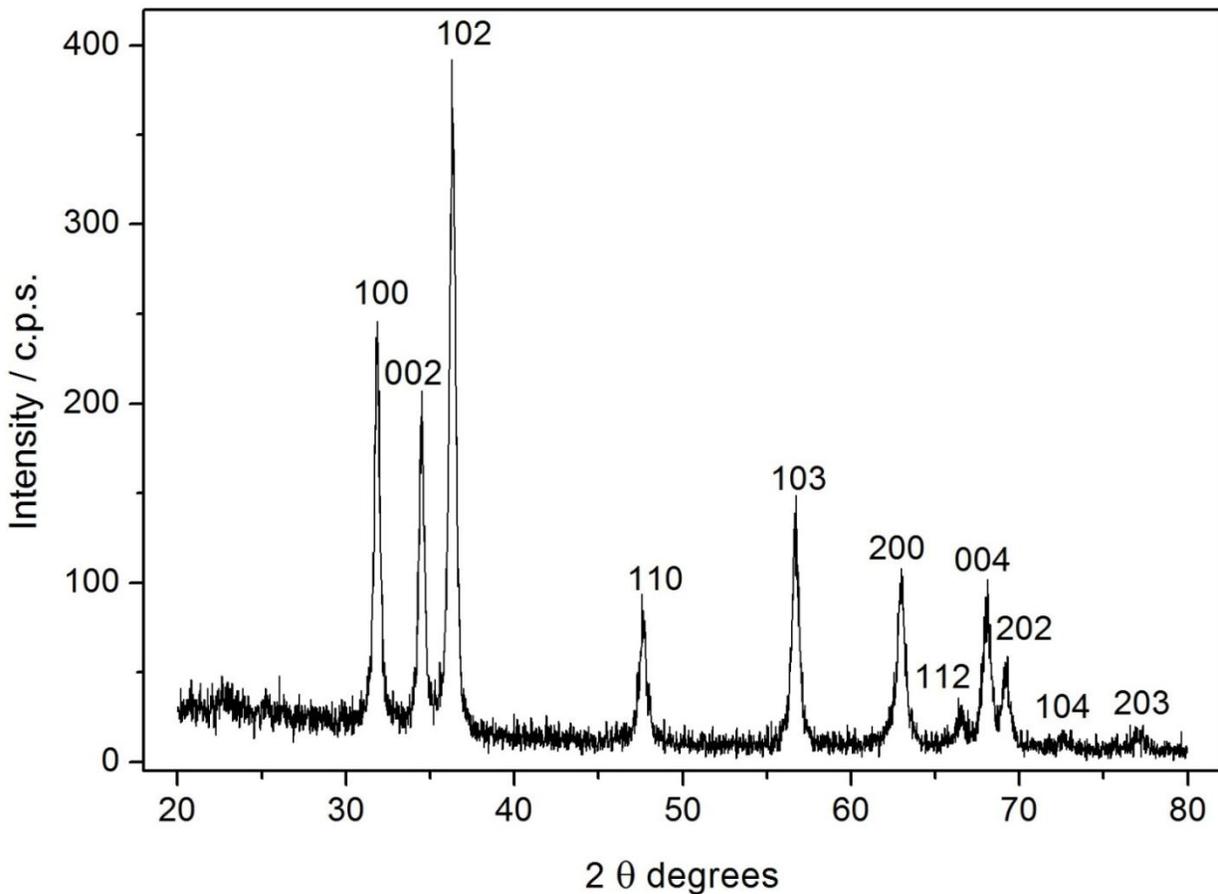


Fig.17 : XRD image of ZnO NPs 60:1

XRD spectrum showed diffraction peaks around 37° , which are indexed the (102) of the wurtzite crystal structure of ZnO. These sharp Bragg peaks might have resulted due to capping agent stabilizing the nanoparticle. Intense Bragg reflections suggest that strong X-ray scattering centres in the crystalline phase and could be due to capping agents. Independent crystallization of the capping agents was ruled out due to the process of centrifugation and redispersion of the pellet in millipore water after nanoparticles formation as a part of purification process. Therefore, XRD results also suggested that the crystallization of the bio-organic phase occurs on the surface of the ZnO nanoparticles or vice versa. Generally, the broadening of peaks in the XRD patterns of solids is attributed to particle size effects. Broader peaks signify smaller particle size and reflect the effects due to experimental conditions on the nucleation and growth of the crystal nuclei.

CONCLUSION

The ZnO nanoparticles were prepared by using seed extract of *Abrus precatorius* called as green synthesis. The phytochemicals present in the plants reduced zinc acetate (). By UV- visible spectrophotometer we found that the band was observed around 386 – 450 nm which was identified as “surface Plasmon resonance band” and this band is ascribed to excitation of valence electrons of ZnO arranged in the nanoparticles (nanocrystal/ nanosphere) .The size of particles formed were 90 nm and 500 nm studied by the particle size analyzer. XRD analysis put forward that the particles was crystalline in nature and has 102 atomic arrangement i.e the particles are arranged in Wurtzite crystal. SEM of the ZnO sample shows that agglomeration has been taken place. The particle size is irregular to some extent spherical. zeta potential showed that surface potential of NPs was found to be 12 mV i.e, incipient instability. FTIR Identified the possible biomolecules responsible for the reduction of ZnO and capping agent of bio-reduced ZnO NPs through particular bond vibrations peaks coming at defined wavenumbers .

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