SYNTHESIS AND CHARACTERIZATION OF ZINC OXIDE GREEN NANOPARTICLES

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Abstract: Nanofluids are nanotechnology based colloidal suspensions fabricated by suspending nanoparticles in a base liquid. These fluids have shown potential to improve the heat transfer. Nanofluids are prepared by dispersing and stably suspending nanometre sized solid nanoparticles in conventional heat transfer fluids, which open up a new field of scientific research and innovative applications. This study aims to the synthesis of green nanoparticles for the development of ZnO nanofluids. Among the metal oxide nanoparticles, ZnO is interesting because it is highly stable, non-toxic and eco-friendly. The green synthesis is done by using the aqueous solution of Aloe Vera leaf extract. The nanoparticles were characterized by transmission electron microscope (TEM) and X-ray diffraction (XRD) method. The average particle size of the powder is determined by XRD. The shape of the particles is decided from the images of transmission electron microscopy. Results indicated the spheroidal shaped particles of an average size 17 nm.

Index Terms **-** *Synthesis1, Zinc oxide2, Green nanoparticles3, Spheroidal shape4* etc…..

I. INTRODUCTION

Heat exchange is one of the major processes used in many industrial systems. Improvement of energy efficiency of heat exchange process of the thermal system is the challenge that the industrial sector is facing. Poor thermal properties of heat transfer fluids puts a limitations on use of energy conservation and efficiency for the development of heat exchange processes. The appropriate use of heat transfer fluids and material in heat exchanging devices leads to considerable saving in overall energy consumption pattern of the plant. Therefore, it is necessary to invent the new alternative heat transfer fluids with nanotechnology.

Nano-fluid is one of the alternatives to conventional heat transfer fluids. Nanofluids are formed by suspending metallic or non-metallic oxide nanoparticles in traditional heat transfer fluids. Such fluids display good thermal properties compared with fluids conventionally used for heat transfer. The nanofluids have opened various areas such as for thermal systems in heat transfer applications to enhance the heat transfer coefficient and efficiency of the system, in the biomedical that have various functions like an antimicrobial wound healing, anti-inflammatory properties etc… [1]. the latest literature reveals that the use of nanofluids in thermal systems is one of the best options to increase energy efficiency of heat transfer equipment's. Buongiorno (2006) concluded, due to enhanced thermo-physical properties, heat transfer capacity of nanofluids is more than base fluid from which it is prepared. Synthesis of nanoparticles is a first step towards development of nanofluids.

B. Sonage and P. Mohanan (2014) synthesized ZnO nanoparticles by direct oxidation of metals. The synthesis of nanoparticles by chemical method generates a large amount of hazardous by products. Thus there is a need of "Green synthesis" by biological procedure which is clean, eco-friendly and environmentally nontoxic. S. Gunalan et.al (2012) synthesized the ZnO nanoparticles by both chemical and biological methods. They used Aloe Vera leaf extract as a natural reducing agent for synthesize the ZnO nanoparticles by biological method. G. Bhumi and N. Savithramma (2014) ZnO nanoparticles by biological method from Catharanthusroseus leaf extract for antibacterial activity. S. Azizi (2013) manufactured ZnO nanoparticles from brown marine macro algae and expected the notable applications in pharmaceutical, biomedical and in cosmetic industries. Other than ZnO nanoparticles J. Thakker (2013) synthesized gold nanoparticles using Fusariumoxysporum. R. Dwivedi (2013) biosynthesized silver nanoparticles by using two medicinal plant extracts i.e. from Jasminumgrandiflorum and Cymbopogoncitrullus. Ertan et.al (2013), S. Gunalan (2012) and G. Bhumi (2014) observed ZnO nanoparticles as an antibacterial, antifungal activity. And also ZnO being as an environment friendly and stable material.

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 antioxidant 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 nontoxic material for the stabilization of the nanoparticles.

II. MATERIALS AND METHODS

Zinc nitratehexahydrate (96% purity) were used as the introductory material supplied by Merck Specialities Pvt. Ltd., Mumbai. Fresh and healthy leafs of Aloe Vera were collected from Walchand College of Science Botanical Garden, Solapur, Maharashtra, India. Primarily the leafs were washed with distilled water, cleaned and used for experimental studies.

Aloe Vera (*Aloe barbadensis*Miller) is a perennial plant of the Xanthorrhoeaceae family. Aloe vera is well known for its succulent leaves and the medicinal and cosmetic properties of the gel obtained from them. It is widely cultivated around the world, but has escaped from cultivation and become naturalized in the warm regions of the Mediterranean, Northern Africa, the Indian subcontinent, South America, and the Caribbean, which makes it quite difficult to correctly establish its origin. It is supposed to be native to North Africa or the Nile region in Sudan. The genus *Aloe* contains over 400 different species, and *Aloe barbadensis*, *Aloe arborescens*, and *Aloe chinensis* are the most popular. *Aloe barbadensis* miller is considered the most biologically active species. The leaf parenchyma (aloe gel) is colourless and tasteless, and has been used particularly in the treatment of skin diseases [6]. The gel consists primarily of water (> 98%) and polysaccharides such as pectin, cellulose, hemicellulose, glucomannan, acemannan and mannose derivates. The ten main areas of chemical constituents of Aloe vera include: amino acids, anthraquinones, enzymes, minerals, vitamins, lignins, monosaccharide, polysaccharides, salicylic acid,

saponins, and sterols. Enzymes act as biochemical catalysts that break down the proteins we eat into amino acids. It is also used as a natural reducing agent in pharmaceutical and biomedical field [14].

Preparation of the Materials

In biological method, Aloe Vera leaf broth extract were prepared with distilled water and made up to 250 ml. Zinc nitrate was then dissolved in the Aloe extract solution under constant stirring using electric stirrer. After complete dissolution of the mixture, the solution was kept under vigorous stirring in bottle flask at 150 ℃ for 5 hours and then is allowed to cool at room temperature. The pale white solid product obtained was then filtered using suction funnel and washed with ethanol and dried at 75 ℃ for 7 hours. ZnO nanoparticles were obtained after calcinations of the solids in furnace at 400 ℃ for 2 hours. The obtained zinc oxide (ZnO) powder is collected and used for further characterization study.

III. CHARACTERIZATION OF GREEN NANOPARTICLES

A white colour powder formed at the end of the biosynthesis process is collected and used to determine size and shape of the particles. The size of the particle is determined by using X-ray powder diffractometer (XRD). In this testing, the powder is exposed to X-rays in XRD machine (Regakuminiflex-II, Japan) to get glancing angle(θ) at different intensities. The XRD pattern which is a graph of intensity verses 2θ is obtained as shown in fig. 1. The XRD pattern is coordinated with JCPDS (Joint Committee for Powder Diffraction Studies of International center for Diffraction data, USA) data file number 79-0206 to confirm about the presence of the Zinc Oxide. Obtained XRD pattern is matching with JCPDS data which confirmed that the powder is of Zinc Oxide.

The crystalline size of nanoparticles is determined by using the data from XRD pattern and Scherrers equation (eq.1). The size of the Zinc oxide nanoparticles is found to be 17 nm.

$$D = \frac{C\lambda}{\beta \cos\theta} \qquad (1)$$

Where, β= Full width at half maximum of X-ray peak in radians.

D= Crystalline size in $A°$

λ= X-ray wavelength = 1.54056 $A°$

C= Correction factor taken as 0.9

The shape of nanoparticles is best studied by transmission electron microscopy (TEM), which gives two types of information in routine examination. The first is the particle size distribution, which is normally represented in terms of a mean diameter and a standard deviation. The second type of information is the crystallinity of a sample obtained through electron diffraction or Nano-diffraction. More detailed information on particle shape, phase transitions, two- and three- dimensional ordering and evaluation of other properties are possible using TEM.

The sample is tested in the Indian Institute of Technology, Bombay and observed under TEM to decide about morphology of the particle. From the TEM testing it is confirmed that the sample is in the Nano range. TEM images taken at different fields of the powder and at different magnification are presented in the fig. 2a to 2c. From fig.(a) it is observed that the nanoparticles remains in aggregated from Fig. (b), (c) indicated the shape of particle as spheroid.

Figures

Figure 1

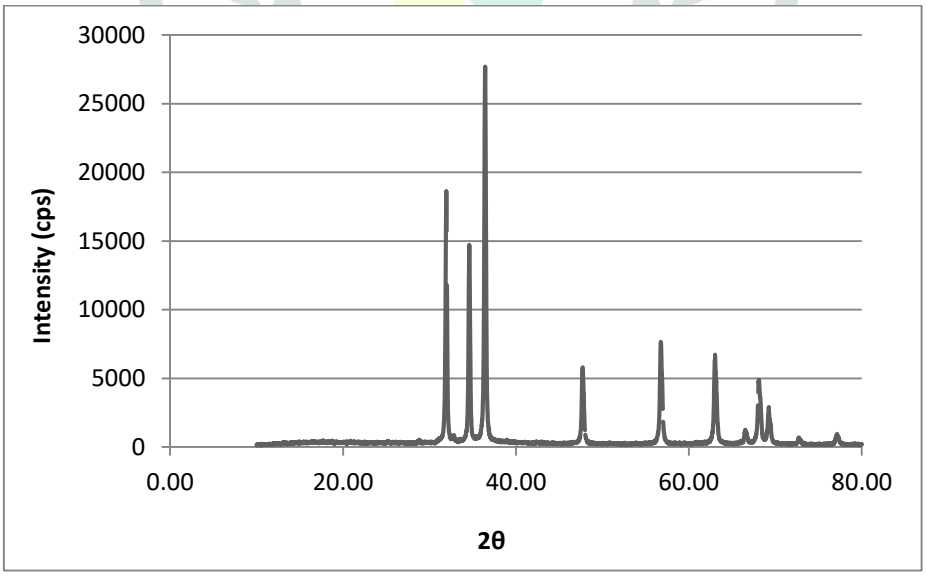


Figure 2 a

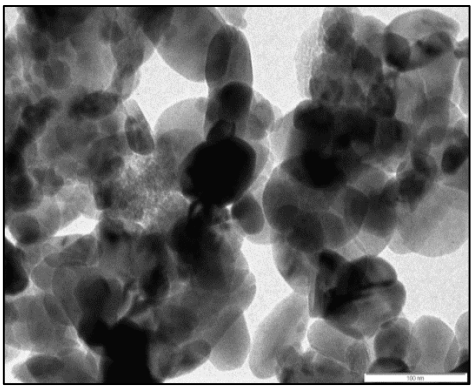


Figure 2b

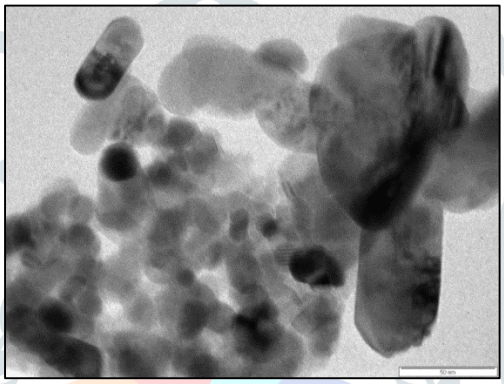
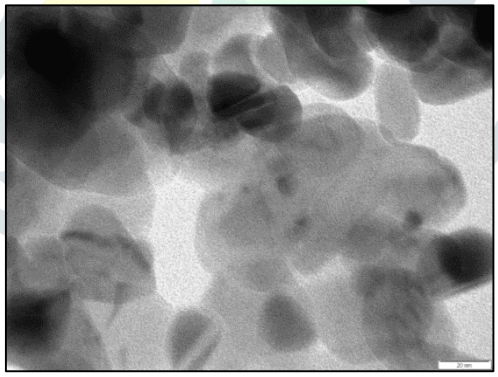


Figure 2c



IV. CONCLUSION

Biosynthesis method can be successfully used for the manufacturing of nanoparticles which can be further used for synthesis of nanofluids. Zinc oxide particles manufactured by biological synthesis method remains in aggregated form. The average crystalline size of the particles, determined by powder diffraction technique, is observed as 17nm and the shape observed by transmission electron microscope as a spheroid shape. As size of the synthesized particles is less than 100 nm, it can be used for preparation of nanofluid.

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