PREPARATION AND CHARACTERIZATION OF ZINC OXIDE NANOFLUID IN ORGANIC COMPONENTS

Rupesh Kumar Malviya[1] , **Manish Verma**[2] **Vinay Yadav**[3]
Dept of Mech Engg Dept. of M.E. Dept. of Mech Eng.
AISECT University, Bhopal (MP)[1] C.E.C., Bilaspur (C.G.)[2] AISECT University, Bhopal (MP)[3]

ABSTRACT

The object of the present work is to the preparation of ZnO nanofluid. This work summaries characterization of ZnO nanofluid. Nanofluid is a stable colloidal suspension of low volume fraction of ultrafine solid particles in nanometric dimension dispersed in conventional heat transfer fluid to offer a dramatic enhancement in conductivity. A approach of synthesis of(ZnO) nanoparticles by chemical precipitation method nanofluids has been adopted here. Nano particles were characterized by x-ray diffraction (XRD), scanning electron microscopy (SEM),dynamic light scattering particle size analyzer, UV-visible characterization.

I.

I. INTRODUCTION

Nanofluids are a new class of fluids engineered by dispersing nanometer-sized materials (nanoparticles, nanofibers, nanotubes, nanowires, nanorods, nanosheet, or droplets) in base fluids. In other words, nanofluids are nanoscale colloidal suspensions containing condensed nanomaterials. They are two-phase systems with one phase (solid phase) in another (liquid phase). Nanofluids have been found to possess enhanced thermophysical properties such as thermal conductivity, thermal diffusivity, viscosity, and convective heat transfer coefficients compared to those of base fluids like oil or water. It has demonstrated great potential applications in many fields. In this dissertation work will review the progress in the methods for preparing stable nanofluids and summarize the stability mechanisms.

II. METHODOLOGY

Zinc oxide (ZnO) nanoparticles were synthesized by chemical precipitation method. Homogeneous solutions of zinc nitrate and sodium hydroxide were prepared in an aqueous media. The soluble starch was added as stabilizing agent. Soluble starch (0.5%) was dissolved in 500 ml of distilled water and treated in microwave oven (domestic oven) for complete solubilization. Zinc nitrate, roughly 15.00 g (0.1 mol), was added in the above solution. Then the solution was kept under constant stirring at room temperature using magnetic stirrer for one hour. After complete dissolution of zinc nitrate, 300ml (0.2 mol), of sodium hydroxide solution was added under constant stirring, drop by drop touching the walls of the vessel. The reaction was allowed to proceed for 2 hrs after complete addition

of sodium hydroxide. After the completion of reaction, the solution was allowed to settle for overnight and the supernatant solution was then discarded carefully. The remaining solution was centrifuged at 10,000g for 10 min and the supernatant was discarded. Thus produced nanoparticles were washed three times using distilled water. Washing was carried out to remove the byproducts and the excessive starch that were bound with the nanoparticles. After washing, the nanoparticles were dried at 80°C for overnight. During drying, complete conversion of Zn $(OH)_2$ into ZnO takes place.

As a capping agent poly (N-vinyl-2pyrroledone) (PVP) was also added to the reaction medium i.e. for controlling the particle size. First, no surface-capping agent has been used for the stabilization of the nucleated particles; instead, the nanoparticles are allowed to interact freely in the aqueous medium. In the second attempt PVP (2 % at. wt) was added in 0.5 molar zinc acetate and then 0.5 M sodium hydroxide was added drop wise. The precipitate appears soon after the addition of sodium hydroxide. The stirring was further allowed for 15 minutes at room temperature using a magnetic stirrer. The precipitated particles were filtered using whatman 40 filter paper. To remove the last traces of adhered impurities, the particles were washed several times using double distilled water. The washed particles were dried at 60ºC in air.

III. RESULT

(i) XRD-Characterization

X-ray diffraction patterns were taken to examine the crystal structure of the products. Fig.1 (a) and (b) shows a typical XRD pattern of the pattern of synthesized capped and uncapped ZnO nanoparticle.Due to the crystal symmetry and related face geometry, the common crystal habit of ZnO is hexagonal in shape. The width of the peaks in case of ZnO nanoparticles has increased due to the quantum size effect. Both shows three broad peaks corresponding to the (101), (002) and (100) along with (102) planes.

(ii) SEM-Characterization

Fig.2(a) shows the general morphology of the uncapped ZnO naanoparticles. This image was taken at the different magnification. The image clearly shows the formation of irregular shape of ZnO nanoparticle. Careful examination of the individual formed of nanoparticle ZnO indicates that the diameters of the particles vary from 15-40 nm. The higher magnification view is shown in Fig.2(b). It is interesting to observe a irregular hexagon-shaped pyramid like nanoparticles grown in the chemical bath. The SEM results of the synthesized capped powders are shown in Fig.3 (a) and (b) at the different magnification. It is clear that PVP capped ZnO nanoparticles are un-agglomerated and uncapped are agglomerated .

(iii) Dynamic light scattering particle size analyzer

The Fig.4. shows the particle size distribution of the ZnO samples. Statistically data was optimized and plotted in terms of volume fraction with sizes. After analyzing data, it was found that only 57 %

ZnO nanoparticle size were in this range of 12-15nm. 21 % particles were in the range of 40-50 nm and only less than 5% particles in the 80-90 nm sizes.

(iii) UV-Visible characterization

As the energy band structure and band gap reflects on the optical properties of the semiconductors, optical absorption spectroscopy is one of the important tool to probe the energy band gap. The UV-Vis spectra of ZnO nanoparticles prepared with 0.5% concentration of soluble starch was shown in Fig.5. The absorption peak of the prepared nano ZnO was found at around 333.78nm. Uncapped ZnO nanoparticles have absorption edge (Fig.5) at 333.78 nm and PVP capped ZnO nanoparticles have absorption edge at 296.95 nm. So band gap of PVP capped ZnO nanoparticles comes out to be 4.42 eV and for uncapped ZnO nanoparticles it is 4.17 eV Band gap of the nanoparticles is calculated from $E = hc/\lambda$ Where E is Band gap energy, h is planck's constant, c is velocity of light, λ is wavelength of absorption edge in reflectance spectra.

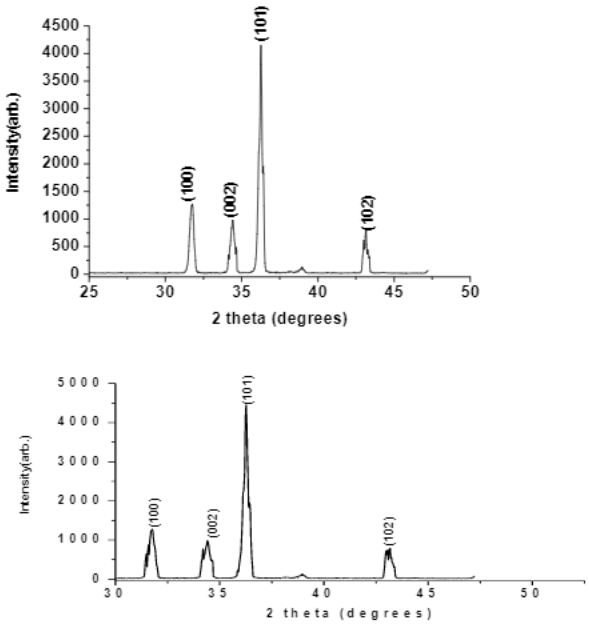

Fig-1- XRD pattern of and uncapped (a) and (b) PVP capped ZnO nano-particles.

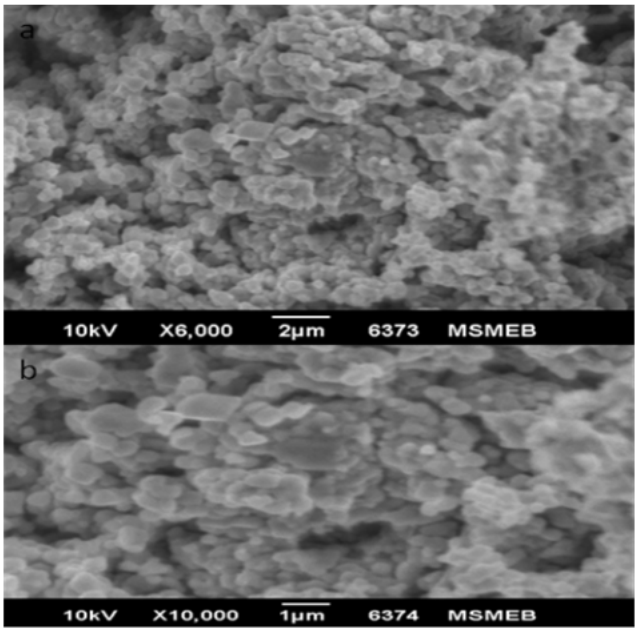

Fig.2. SEM micrograph of uncapped ZnO nano-particles synthesized by chemical precipitation method.

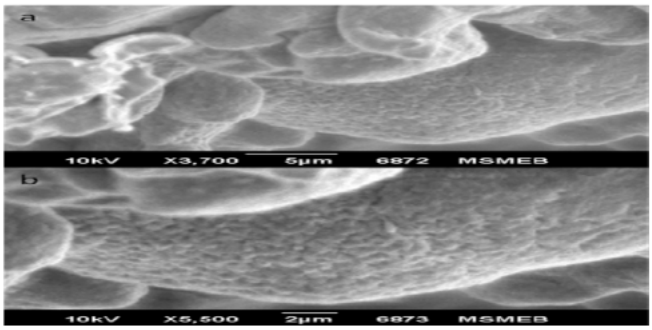

Fig.3. SEM micrograph of Capped ZnO nano-particles synthesized by chemical precipitation method.

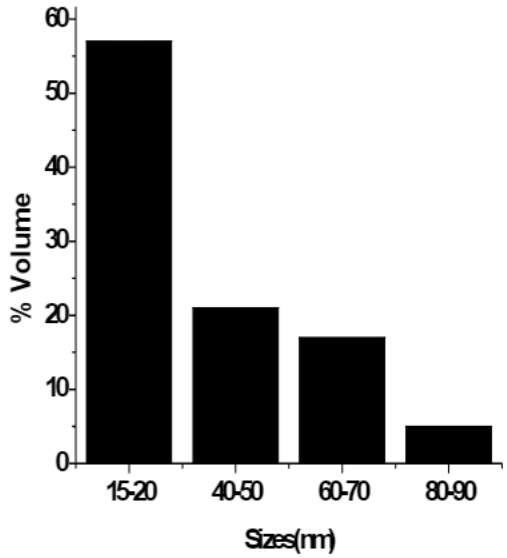

Fig.4. Particle size distribution of ZnO nano-particles synthesized by chemical
Precipitation method

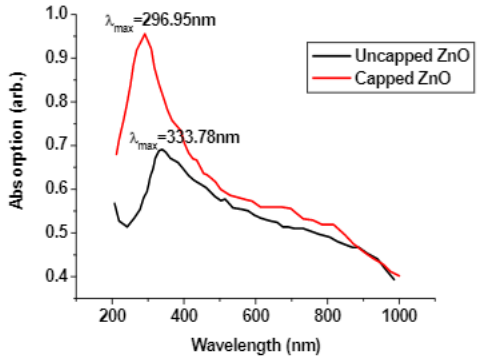

Fig.5. UV-Vis spectra of the ZnO prepared with 0.5% of soluble starch

IV. CONCLUSION

The following conclusions can be drawn from the present investigation:

1. It is possible to synthesizes ultrafine ZnO nanoprticles through chemical precipitation.

2. Observed in the XRD patterns match well with those of the ZnO reported in the JCPDS Powder Diffraction. Intensities of the three most important peaks of ZnO, namely <101>, <100> and <002> reflections corresponding to 36.36°, 31.84° and 34.30° respectively do not deviate from the Powder Diffraction File intensities.

3.General morphology of the uncapped ZnO nanoparticles trough SEM. This image was taken at the different magnification. The image clearly shows the formation of irregular shape of ZnO nanoparticle. It is clear that PVP capped ZnO nanoparticles are un- agglomerated (Fig.4.3a) and uncapped are agglomerated (Fig.4.3b)

6.Dynamic light scattering particle size analyzer analyzing data, it was found that only 57 % ZnO nanoparticle size were in this range of 12-15nm. 21 % particles were in the range of 40-50 nm and only less than 5% particles in the 80-90 nm sizes.

7. The UV-Vis spectra of ZnO NP prepared with 0.5% concentration of soluble starch was shown in Fig 4.5. The absorption peak of the prepared nano ZnO was found at around 333.78nm. Uncapped ZnO nanoparticles have absorption edge (Fig-4.5) at 333.78 nm and PVP capped ZnO nanoparticles have absorption edge at 296.95 nm.

V. FUTURE SCOPE

The present work leaves a wide scope for future investigators to explore many other aspects like study of thermal conductivity, viscosity and convective heat transfer of nanofluids. The electrokinetic phenomena of nanofluids like long term stability and particle interactions in the base fluids can also be studied.

REFERENCE

[1] Ryogo, K., J. Phys. Soc. Jpn., 17 (16) (1962) pp. 876–880.

[2] Rohrer, H., The Nanoworld: Chances and Challenges, Microelectronic Engineering, 32 (1996) No. 1-4 pp. 5-14.

[3] Choi, S.U.S., Enhancing Thermal Conductivity of Fluids with Nanoparticles:Developments and Applications of Non-Newtonian Flows, America Society of Mechanical Engineers (ASME) 66 (1995) pp. 99.

[4] Masuda, H., Ebata, A., Teramae, K., Hishiunma, K., Alternation of thermal conductivity and viscosity of liquid by dispersing ultrafine particles (dispersion of Al2O3, SiO2 and TiO2 ultrafine particles) Netsu Busei (Japan) 4 (1993) pp. 227-233.

[5] Krishnamurthy, S., Bhattacharya, P., Phelan, P.E., Prasher, R.S., Enhanced mass tran in nanofluids, Nano Letter 6 (3) (2006) pp. 419–423.

[6]. Wasan, D.T., Nikolov, A.D., Spreading of nanofluids on solids, Nature 423 (2003) pp. 156–159.

[7]. U. S. Choi, Z. G. Zhang, W. Yu, F. E. Lockwood, and E. A. Grulke (2001) Anomalously Thermal Conductivity Enhancement in Nanotube Suspensions. Applied Physics Letters 79: 2252–2254.

[8] S. U. S. Choi (1995), Enhancing Thermal Conductivity of Fluids with Nanoparticles, in Developments and Applications of Non-Newtonian Flows, eds. D. A. Singer and H. P. Wang, vol. FED 231, pp. 99–105, American Society of Mechanical Engineers, New York.