Synthesis, Characterization And Thermodynamic Study of Zinc Oxide (ZnO) Nanofluids

P. D. Bageshwar [1], N. R. Pawar [2]
[1, 2] Dept of Physics
[1]M. M. College, Darwha – 445 202, India
[2]Arts, Commerce & Science College, Maregaon – 445 303, India

Abstract- *Nanofluids have attracted greater interest in recent years because of their enhanced thermal conductivity in comparison to that of the base fluids. Therefore, nanofluids can be used as a better heat transfer fluid in the heat exchange systems. Nanoparticles find their wide applications in fields like electronic applications, transportation, industrial cooling application, heating buildings and reducing pollution, nuclear system cooling, space and defense, energy storage, solar absorption, friction reduction, magnetic sealing, antibacterial activity, nondrug delivery, vehicular brake fluids, nanofluids based microbial, fuel cell, and nanofluids based optical filters and sensors. Nanoparticles are expected to have a surface to volume ratio given as large surface to volume ratio proportional to the inverse of particle size of nanomaterials changes the role played by the surface atoms in determining their thermodynamic properties In this work, zinc oxide nanoparticles were readily synthesized through sol-gel method using Zinc acetate [Zn (CH3CO2)2.2H2O] as precursor and sodium hydroxide (NaOH) as solvent. Synthesized sample were characterized by techniques XRD and SEM. Average particle size has been estimated by using Debye-Scherrer formula. It was found to be 30 nm. ZnO nanofluids were prepared by two step method in methanol base fluid and did their thermodynamic study related to the surface of nanoparticle and nanoparticle surfactant interactions [1-4].*

Keywords- ZnO; material characterization; thermodynamic study; XRD

Highlights

- ZnO nanoparticles synthesized via sol-gel method.
- Thermodynamic behavior of ZnO nanofluids depends on specific surface area of nanoparticles.

I. INTRODUCTION

ZnO nanostructures have a great advantage to apply to a catalytic reaction process due to their large surface area and high catalytic activity. Since zinc oxide shows different physical and chemical properties depending upon the morphology of nanostructures. The physical and chemical properties of synthesized zinc oxide are to be investigated in terms of its morphology. In the present work we have prepared inorganic ZnO nano powder by process sol-gel method and characterization by X-ray diffraction (XRD) technique. Elastic properties of nanoparticles suspension are characterized by ultrasonic testing. The method is also used for investigation of aggregation process under the influence of different temperature. All real fluids are compressible and compression waves can propagate in most fluids.

II. SYNTHESIS OF ZnO

Zinc oxide nanoparticles were readily synthesized through sol-gel method using Zinc acetate [Zn $(CH_3CO_2)_2$.2H2O] as precursor and sodium hydroxide (NaoH) as solvent. Zinc acetate was dissolved in sodium hydroxide by the molar ratio 1:85. After stirring the solution at 75^0 C for 4 hours, filtration was done by whatman filter paper. During the filtration solution was washed by ethanol many times to avoid the impurities. After filtration, filtered sample was heated at 90^0C in oven for 2 hours to get white luminescent powder [5-7].

III. CHARACTERIZATION

XRD:

The compounds were characterized for their structure and morphology by XRD. The prepared powder samples were characterized for their phase purity and crystallinity by X-ray powder diffraction (XRD) using PAN-analytical diffractometer (Cu-Ka radiation) at a scanning step of 0.01^o, continue time 20 s, in the 2h range from 10^o to 120^o. From this study, average particle size has been estimated by using Debye-Scherrer formula [8-10].

$$D = \frac{0.9\lambda}{W Cos\theta} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

SEM images of the samples were taken using a Philips XL 30 ESEM scanning electron microscope (FEI-

Philips Company, Hillsboro). The XRD pattern of ZnO nanoparticles are represented in fig.1.

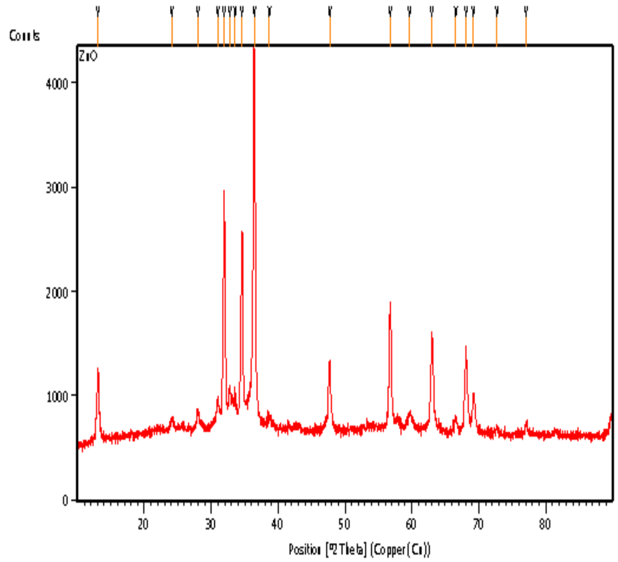

Fig.1 XRD pattern of ZnO nanoparticles

IV. RESULTS AND DISCUSSION

Fig.2 represents the nonlinear variation of sound velocity of ZnO nanoparticles in methanol base fluid. Sound velocity can be interpreted as the nanosize ZnO particles have more surfaces to volume ratio and which can absorb more methanol molecules on its surface, which enhances the sound velocity. Non linear variation of sound velocity may due to the Brownian motion of nanoparticles. Aggegation of nanoparticles in nanofluids may occurs due to the interstitial accommodation.

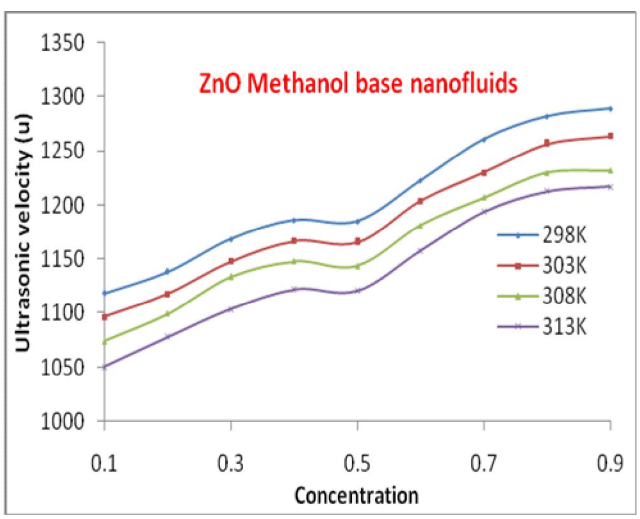

Fig. 4 Sound velocity of ZnO nano particle in methanol base fluid

Fig.3 shows the variation of thermal conductivity with molar concentration of ZnO nanoparticles in methanol. The results clearly show that the effective thermal conductivity of ZnO increases with temperature. A maximum in the thermal conductivity versus *t*emperature behavior was observed for various molar concentrations. Nanoparticle suspensions, containing a small amount of ZnO have substantially higher thermal conductivity than the base fluid. The enhanced thermal conductivity increases with an increase in the molar concentration and temperature. The thermal conductivity enhancements are highly dependent on specific surface area (SSA) of nanoparticle, with an optimal SSA for the highest thermal conductivity.

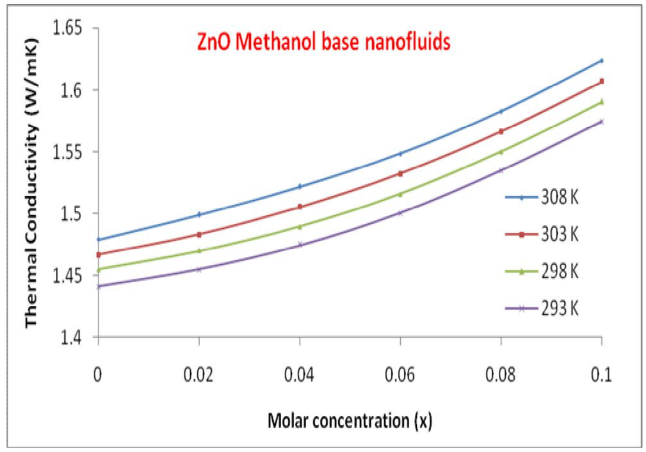

Fig:3 Thermal conductivity versus molar concentration of ZnO nano particle in methanol

Fig.4 shows the variation of Gibbs free energy with molar concentration of ZnO nanoparticles in methanol base fluid. Gibbs free energy of ZnO nano suspension increases with increase in molar concentration of ZnO nanoparticles in methanol. This indicates the stability of ZnO nanoparticles in methanol base fluid. Stability decreases with increase in molar concentration, it is more unstable at 0.8.

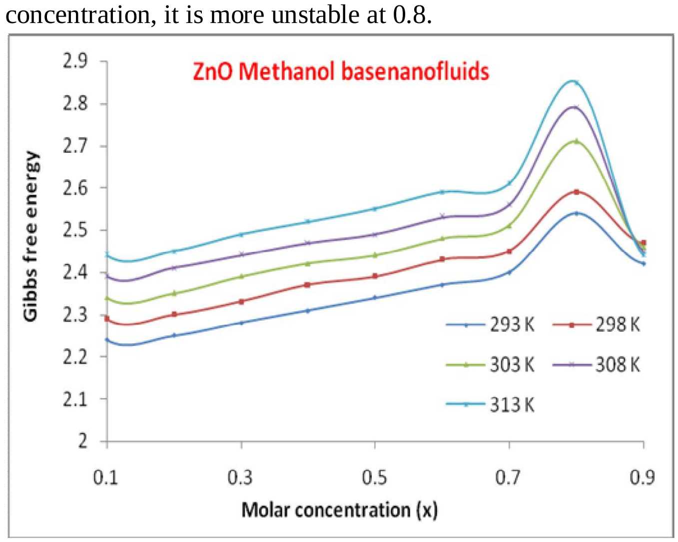

Fig. 4 Gibbs free energy of ZnO nano particle in methanol base fluid

V. CONCLUSIONS

1. The structural, optical and thermal properties of the α-Al_2O_3 nanoparticles and methanol base nanofluids are characterized by XRD, sound velocity, Gibbs free energy and thermal conductivity.
2. Brownian motion of ZnO nanoparticles in methanol base nanofluids and thermal agitation are responsible for nonlinear variation of sound velocity
3. Reduced size of the nanoparticles reduces the surface energy through surface relaxation.

REFERENCES

[1] Shingo T., Atsushi N., Takeharu T. and Hiroyuki Wada, Materials 4 (2011) 1132-1143.
[2] Tanujjal B., Karthik K. L., Soumik S. and Joydeep D, Journal of nanotechnology, 4 (2013) 714- 725.
[3] Wang B.X., Zhou L.P. and Peng X.F., Mechanism of heat transfer in nanofluids, *Prog. Nat. Sci.,* **14** (2004) 36-41.
[4] Riyadh M. Alwan, Quraish A. Kadhim, Kassim M. Sahan, Rawaa A. Ali, Roaa J. Mahdi, Noor A. Kassim, Alwan N. Jassim, Nanoscience and Nanotechnology 5 (2015) 1-6.
[5] Liu M.S., Lin M.C.C., Huang I.T. and Wang C.C., Enhancement of thermal conductivity with CuO for nanofluids, *Chem. Eng. Technol.*, 29 (2006) 72-77
[6] Kulkarni D.P., Das D.K. and Chukwu G.A., Temperature dependent rheological property of copper oxide nanoparticles suspensions, *J. Nanosci. Nanotechnol*, 6 (2006) 1150-1154.
[7] D.H. KUMAR, H.E. PATEL, V.R.R. KUMAR, T. SUNDARARAJAN, T. PRADEEP and S.K. DAS, 2004. Model for heat conduction of nanofluids, *Physical Review Letters*, **94**(14), 1-3.
[8] S. RAJAGOPALAN, S. J. SHARMA and V.Y. NANOTKAR, 2005. Ultrasonic Characterization of Silver Nanoparticles, *Journal of Metastable and Nanocrystalline Materials,* **23,** 271-274.
[9] Z. GAN, G. NING, Y. LIN and Y. CONG, 2007. Morphological control of mesoporous alumina nanostructures via template-free solvothermal synthesis. *Mater Lett.* **61**(31), 3758-3761.
[10] X. ZHAN, M. HONKANEN and E. LEVA, 2008. Transition alumina nanoparticles and nanorods from boehmite nanoflakes. *J Crystal Growth*. **310**(30), 3674-3679.