Enhancement in Heat Transfer Performance of ZrO_2/H_2O Nanofluid via Ultrasonication Time

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Abstract— In the present work, heat transfer performance of ZrO_2/H_2O nanofluids was studied as a function of ultrasonication time. The as-prepared nanofluids were characterized by X-ray diffraction, scanning electron microscope and ultraviolet-visible spectroscopy. The X-ray diffraction, scanning electron microscope and ultraviolet-visible spectroscopy characterizations shows that particles size of dispersed ZrO_2 particles decreases with the increase in ultrasonication time, whereas viscosity decreases. Ultrasonication to ZrO_2/H_2O nanofluids showed thermal conductivity enhancement of nearly 5%. The enhancement in thermal conductivity enhancements reflects the nanofluids could be appropriate for cooling applications.
Keywords- *Heat Transfer; Nanofluid; Ultrasonication*

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I. INTRODUCTION

Conventional fluids dispersed with metal oxide nanoparticles are normally used to enhance the thermal conductivity. Now a day these fluids are fundamental part of compactness heat exchangers. Said et al reported the optical properties of metal oxides based nanofluids. This study shows that extinction coefficient and refractive index of TiO2 nanofluids are found higher than Al_2O_3 nanofluids in visible region of light for all concentrations [1]. Colla et al prepared the water-based nanofluids containing iron oxide. This study demonstrated that thermal conductivity of these nanofluids improved with temperature and particles concentration [2]. Baby et al synthesized the metal oxide decorated graphene dispersed nanofluids. Thermal conductivity of CuO decorated graphene dispersed in distilled water based nanofluid shows an enhancement of ~28% at 25 °C [3]. Bhogare et al critically studied the applications and challenges of nano-fluids as coolant in automobile radiator. This study is beneficial to design more compact cooling system with smaller and lighter automobile radiators [4]. Anandan et al reported the stable CuO based nanofluids for efficient cooling. The dispersion of CuO reflects the high thermal conductivity and maintains excellent colloidal stability [5]. Sridhara et al critically reviewed the Al_2O_3-based nanofluids. This study shows that ultrahigh cooling performance of the important needs of many industries [6].

In this study, ZrO_2/H_2O nanofluids were prepared and effects of ultrasonication on thermal conductivity were investigated. The nanofluids are characterized by X-ray diffraction, scanning electron microscope and ultraviolet-visible absorption spectrum. This depiction sheds light on the effect of ultrasonication on thermal conductivity.

II. EXPERIMENTAL

In the present work, ZrO_2 was directly procured from the SD fine, India and used without further purification. The nanofluids were prepared by ultrasonication technique (PCi-750F). The ZrO_2 dispersed water samples were kept for the different interval of time under ultrasonication. The viscosity and thermal conductivity measurements were repeated for four times to determine the repeatability of measurements.

III. RESULTS AND DISCUSSION

Figure 1 shows that XRD patterns of ZrO_2 nanoparticles recovered from fluid after dose of ultrasonication at room temperature (303 K). The diffraction peaks appears in the pattern exactly indexed to the PDF card no.: 01-089-7710. The minute observation of XRD pattern shows that width of diffraction peak increases as a function of ultrasonication time. The particle size of ZrO_2 nanoparticles was estimated using the Scherrer relation [7]. The average particles size of ZrO_2 nanoparticles ranges between 19.2-24.6 nm.

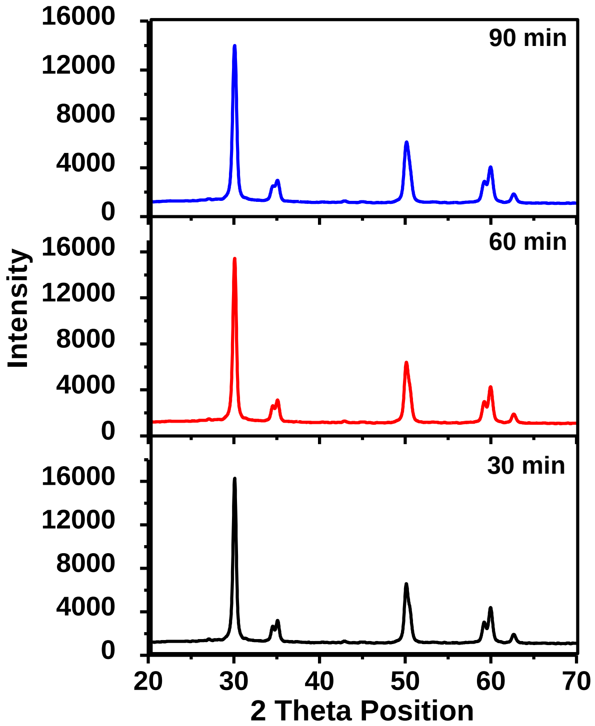

Figure.1. XRD patterns of ZrO_2 nanoparticles.

Fig. 2 shows the SEM images of ZrO_2 nanoparticles recovered from nanofluids kept for different ultrasonication dose. SEM images shows that some amount of agglomeration is present in recovered samples. The average particle size estimated using the XRD analysis is well supported by SEM.

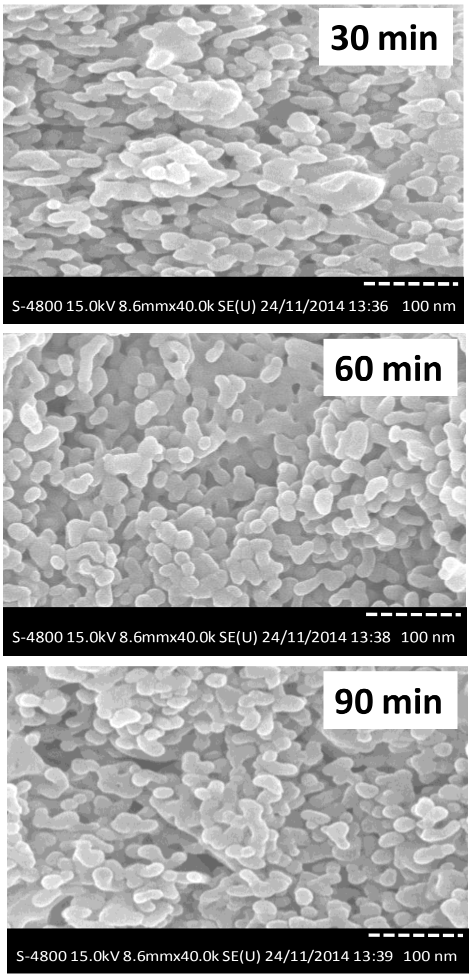

Figure 2. SEM images of ZrO_2 nanoparticles.

Fig.3. shows the UV-VIS spectrum of ZrO_2 nanoparticles recovered from nanofluids. Absorption tail of ZrO_2 nanoparticles found to shift towards the lower wavelength side that is blue shift. This indicates that particles size decrease with an increase in ultrasonication time.

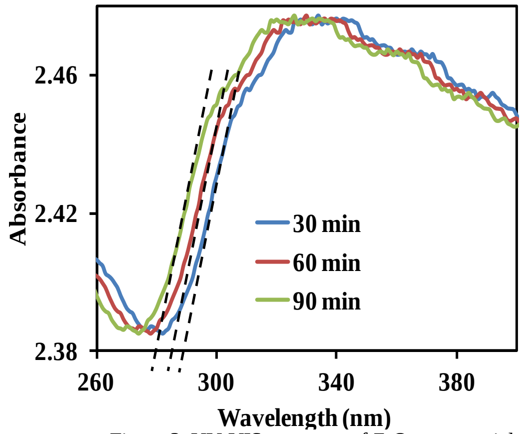

Figure 3. UV-VIS spectrum of ZrO_2 nanoparticles.

Viscosities of ZrO_2/H_2O nanofluids were found to decrease with an increase in ultrasonication time. This shows that Newtonian behavior of ZrO_2/H_2O nanofluids improved with an increase in ultrasonication time [8].

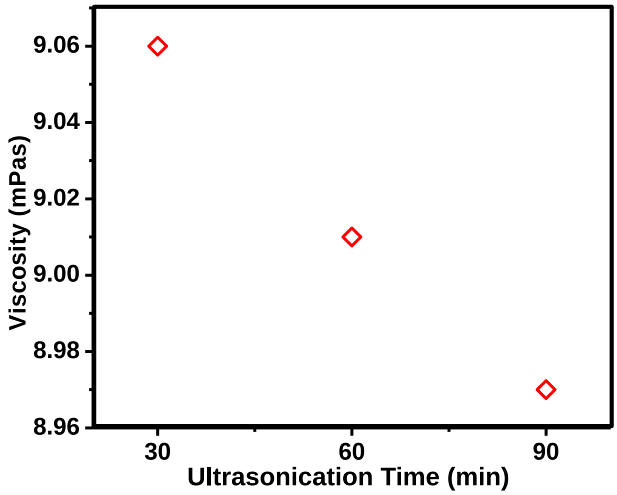

Figure 4. Variation of viscosity with ultrasonication time of ZrO_2/H_2O nanofluids.

Fig. 5 shows the influence of ultrasonication time on thermal conductivity. This enhancement in thermal conductivity of nanofluids attributed to the nanoscale phenomena occurring in the colloidal solid–liquid dispersions and Brownian motion of nanoparticles [9].

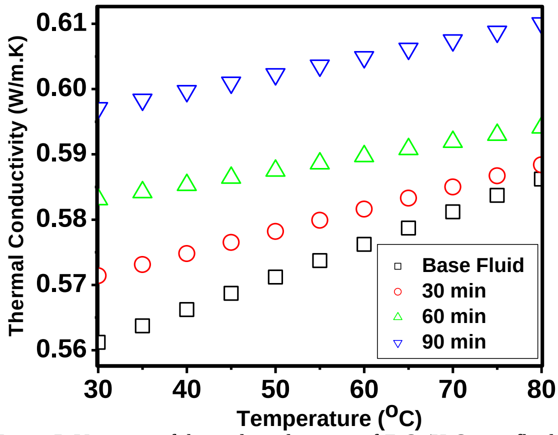

Figure 5. Variation of thermal conductivity of ZrO_2/H_2O nanofluids

IV. CONCLUSIONS

In summary, we successfully demonstrated the effect of ultrasonication time on thermal conductivity of ZrO_2/H_2O nanofluids. The viscosity of ZrO_2/H_2O nanofluids decreases with an ultrasonication time. The enhancement of ~5 % thermal conductivity observed for 90 min ultrasonication time.

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REFERENCES

[1] Z. Said, R. Saidur, N.A. Rahim, "Optical properties of metal oxides based nanofluids," Int. Comm.in Heat and Mass Transfer, vol. 59, pp. 46–54, December 2014.

[2] L. Colla, L. Fedele, M. Scattolini, S. Bobbo, "Water-based Fe_2O_3 nanofluid characterization: thermal conductivity and viscosity measurements and correlation," Adv. Mechanical Engineer., vol. 2012, pp. 1-8, September 2011.

[3] T.T. Baby, R. Sundara, "Synthesis and transport properties of metal oxide decorated graphene dispersed nanofluids," J. Phys. Chem. C, vol. 115, pp. 8527–8533, April 2013.

[4] R.A. Bhogare, B.S. Kothawale, "A review on applications and challenges of nano-fluids as coolant in automobile radiator," Int. J. Scientific and Res. Publications, vol. 3, pp. 1-11, August 2013.

[5] D. Anandan, K.S. Rajan, "Synthesis and stability of cupric oxide-based nanofluid: A novel coolant for efficient cooling," Asian Journal of Scientific Research, vol. 5, pp. 218-227, April 2012.

[6] V. Sridhara, L.N. Satapathy, "Al_2O_3-based nanofluids: a review," Nanoscale Research Letters, vol. 6, pp. 456-472, July 2011.

[7] K.R. Nemade, S.A.Waghuley, "Low temperature synthesis of semiconducting α-Al_2O_3 quantum dots," Ceramics Int., vol. 40, pp. 6109–6113, May 2014.

[8] I.M. Krieger, T.J. Dougherty, "A mechanism for non-newtonian flow in suspensions of rigid spheres," Trans Soc Rheol., vol. 3, pp. 137–152, August 1959.

[9] P Keblinski, S.R. Phillpot, S.U.S. Choi, J.A. Eastman, "Mechanisms of heat flow in suspensions of nano-sized particles (nanofluids)," Int. J. Heat Mass Transf., vol 45, pp. 855–863, February 2002.