EFFECTOF ULTRASONICATION DURATION ONSTABILITY OF GRAPHITE NANOFLUIDS

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Abstract - The effect of ultrasonic duration on the stability of Graphite-Ethylene glycol (EG) and water based nanofluid is reported in this paper. Accordingly, ultrasonication duration of 2 hour, 3 hour and 4 hour was selected for water based nanofluid and ultrasonication duration of 2 hour and 4 hour was selected to prepare EG based nanofluid. Zeta potential analysis for these prepared nanofluids was carried out. UV-vis spectroscopy analysis was performed for EG based nanofluid prepared by ultrasonicating for 3 hours. From the analysis it was observed that the prepared nanofluid have good stability and it increases with increasing ultrasonication duration.

Keywords - Nanofluid, ultrasonication, graphite, ethylene glycol.

I. INTRODUCTION

Nanofluid consists of particles of nanometer size distributed in base fluids. Nanofluids enhance heat transfer phenomena from various application devices like mini/micro channels, with very low sedimentation. However, stability is a major concern as it leads to more preparation cost and reliable performance [1]–[3]. Through Zeta potential analysis and other procedures like UV-vis spectroscopy stability of the prepared nanofluid can be estimated [4], [5]. Few researchers who worked on nanofluid characteristics are mentioned below. Haitao et al., [6]used a simple method to prepare stable graphite suspension by optimization the pH value by using PVP K30 as a dispersant. The enhancement of thermal conductivity was found 34% for the2% volume concentration and also quoted that a graphite nanosuspension could be the attractive candidate for the heat transfer application. Murshed et al., [7] showed that the effective thermal conductivity and viscosity of nanofluids increases significantly with the particle volume fraction.

Tavman et al., [8] examined thermal conductivity and viscosity of water based Alumina and Silica nanofluids for 0.45%, 1.85% and 4% volume concentration and 0.5 and 1.5% volume concentration respectively. The effective thermal conductivity of both nanofluids increases with the increase in volume concentration. Chen et al., [9] examined a thermal conductivity of nanofluids based on the suspension rheology. They have proposed and validated experimentally four types of nanofluids consisting of different nanoparticles and base fluids. It was found that the conventional correlations could not predict the thermal conductivity of nanofluids; however, by incorporating the microstructure parameters obtained from rheological measurements, the thermal conductivity could be predicted precisely.
Duangthongsuk et al., [10] presented an experimental study on the effective thermal conductivity and effective viscosity of TiO2-water nanofluids for volume concentration 0.2 to 2vol%. Jeong et al., [11] conducted experiments on thermal conductivity and viscosity of DI water based ZnO nanofluids, effects of the shape of nanoparticles were also demonstrated. Yapici et al., [12] introduced a review on the rheological conduct of polyethylene glycol (PEG 200) TiO2 nanofluids for more than 1-10 wt% particle mass fraction extend regarding shear viscosity, thixotropy, and linear viscoelasticity by utilizing a stress-controlled rheometer with a cone and plate measuring cell.

Mehrali et al., [13] studied the effect of concentration, surface area and temperature of thermal conductivity and rheological behavior of distilled water based GNP nanofluids. Distilled water based graphene nanoplatelet (GNP) stable nanofluids were prepared by ultrasonication for the mass concentration 0.025, 0.05, 0.075, and 0.1 wt.% with a different specific area of 300, 500, and 750 m2/g.Usri et al., [14] prepared Al2O3 nanofluids by two-step methods by considering three different mixture base ratios as base fluid W: EG (60:40, 50:50 and 40:60) with a volume concentration 0.5% to 2%.
Few other research works related to characterization, preparation of nanofluids are reported in [15]–[21]. However, preparation of Graphite nanofluids with Ethylene Glycol (EG) as base fluid for different ultrasonication duration and its stability analysis is not reported in the literature. In this work, Graphite-EG nanofluids are prepared by different ultrasonication duration and Zeta potential analysis and UV-vis spectroscopy analysis is reported.

II. DETAILS EXPERIMENTAL

2.1. Materials and Procedures

Graphite nanofluids are prepared by a two-step method. Graphite nanoparticles utilized for the study is supplied by Sisco Research Labs. Table 1 shows the properties of graphite nanoparticles

Parameters	Description
Size	<50 nm
Density	2.26 gm/cc
Morphology	Hex-Lamellar
Asay	min.99.5%
Color	Black
pH	6~7

Table 1: Properties of Graphite nanoparticle supplied by Sisco Research Lab

An ultrasonic cleaner (shown in figure 1) is used to prepare graphite nanofluid by ultrasonication to disperse nanoparticles in a base fluid. Nanofluids are prepared by two-step method; initially, for different volume fraction graphite nanopowder weight for the 100 ml of EG fluid is calculated by,

$$\varphi = \frac{\frac{w_g}{\rho_g}}{\frac{w_g}{\rho_g} + \frac{w_{EG}}{\rho_{EG}}} \qquad (1)$$

Where $w_g$is the weight of graphite nanoparticle isρ_g is the density of graphite nanoparticles, w_{EG} weight of ethylene glycol and ρ_{EG} density of ethylene glycol. Weights are measured by electronic balance with an accuracy of 1%.



Fig.1 Ultrasonic cleaner

Graphite nanoparticles with a normal particle size <50nm with the required volume concentration (0.1% and 0.2% for 30 ml of base fluid) is taken in a volumetric flask poured to the pure base fluid(water and EG) after weighting. In the wake of including nanoparticles and base fluid in a volumetric flask, a little quantity of PVP-30 (polyvinylpyrrolidone) is included for scattering and is combined physically. To guarantee a steady, uniform and continuous suspension, the scattering arrangements are sonicated in an ultrasonic cleaner (Sidilu c-built, ±37 kHz) provided by Sidilu Renewable Energy, Bengaluru for 2 hour and 3 hour for water based nanofluid and 2 hour and 4 hour to prepare EG based nanofluid. During sonication, the temperature varies due to perpetual sonication, in the range of 40 ºC ~ 60 ºC.

Horiba SZ-100-Z is used for the measuring of zeta potential for graphite nanofluids. The Horiba nanopartica SZ-100 provides a simple, expeditious and precise way to quantify zeta potential, and utilizes a unique disposable capillary cell to ascertain that there is no cross-contamination between samples. This is utilized to test the water based nanofluids.

III. RESULTS AND DISCUSSION

3.1.Zeta potential for Water based nanofluids

Zeta potential tests are conducted for water based Graphite nanofluids by varying the ultrasonic duration. Fig.2 shows zeta potential distribution for water based graphite nanofluids which are ultrasonicated for a 2- hour time period(volume concentration 0.1%). Zeta potential value of -33.4 mV is obtained, which demonstrates moderate stability (from literature).

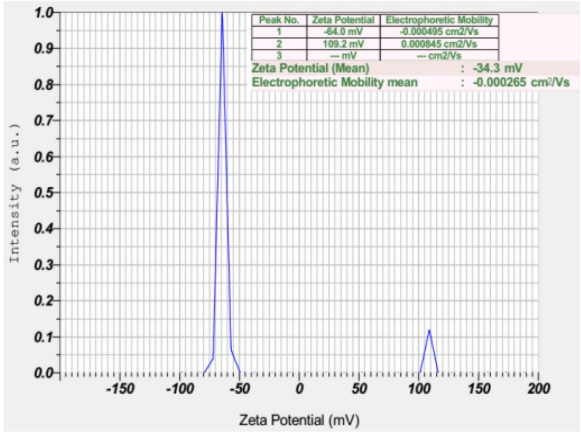


Fig.2: Zeta potential for water based Graphite nanofluids with adding PVP K30 with 2hr Ultrasonication.

Similarly, water based graphite nanofluid was repared for a 3-hour duration and 4 hours of ultrasonication and zeta potential study was performed. Fig.3 shows zeta potential distribution for the water based graphite nanofluids prepared for 3- hour ultrasonication with a zeta potential of -66.2 mV with very good stability.

Hence, water based graphite nanofluids prepared by 3-hour ultrasonication is better stability than 2-hour ultrasonication. In this study, results shows that longer duration of ultrasonication is required for larger particle size to break down the particles from agglomeration to get a uniform and stable suspension.

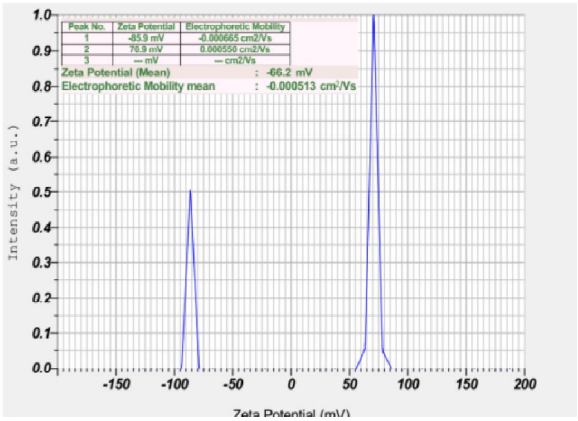


Fig. 3: Zeta potential for water based Graphite nanofluids with adding PVP K30 for <50nm (3hr ultrasonication).

3.2. Zeta potential for EG based nanofluids

Zeta potential study for EG based graphite nanofluids prepared by ultrasonication (2-hour and 4-hour) for was carried out after preparation. Fig. 4 illustrates zeta potential distribution for EG based graphite nanofluids ultrasonicated for 2- hour.

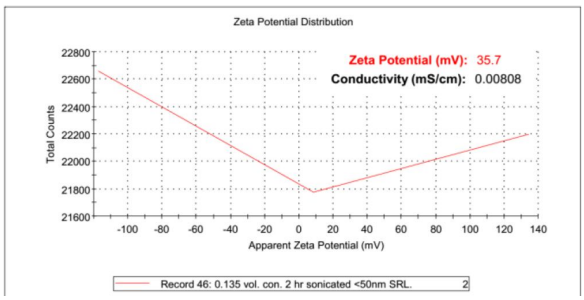


Fig.4: Zeta potential for EG based Graphite nanofluids with adding PVP K30 for 2hour ultrasonication

Zeta potential value of 35.7 mV was obtained with a moderate stability (referring from literature). Water based graphite nanofluid was ultrasonicated for the same duration shown same moderate stability. However, EG based graphite nanofluids prepared with a 4 hour of ultrasonication exhibits -171 mV of zeta potential value as appeared in Fig. 5. Hence EG based graphite nanofluids exhibits very good stability compared to the water based graphite nanofluids are sonicated for the 2-hour, 3- hour and 4- hour time periods.

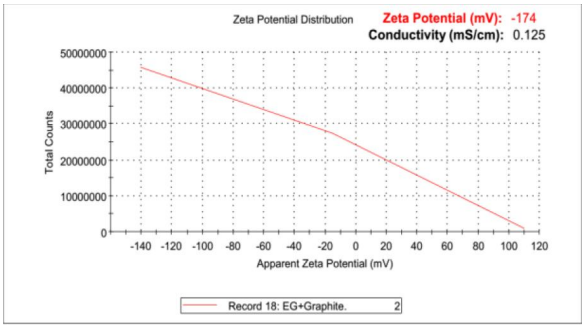


Figure 5: Zeta potential for EG based Graphite nanofluids with adding PVP K30 for <50nm (4hr ultrasonication).

3.3 UV-Vis Spectral analysis

In this study, EG based graphite nanofluids are prepared for two volume concentration (0.1% and 0.2%) by adding PVP as a surface agent. A UV-Vis Spectroscopy study was carried out after preparation by using a standard cuvette size. A standard value of absorbing wave length is obtained for the Graphite nanoparticles dispersed in EG. Fig. 6 and 7 shows the UV-Vis spectroscopy images for dispersion of graphite nanoparticles in EG, an increase in absorbance with increasing wavelength. From the results, a strong absorption band is observed between 450 to 550nm for both volume concentrations which confirms the presence of graphite nanoparticles in EG with a stable condition.

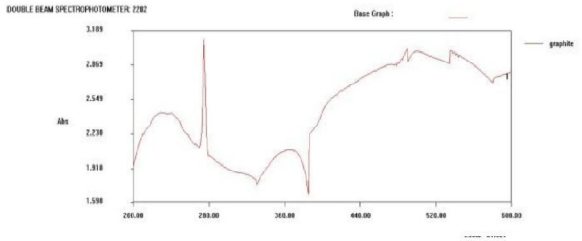


Figure 4.24: UV- Vis Spectroscopy for 0.1 vol graphite nanoparticles (<50nm) suspended in EG (3 hr sonication)

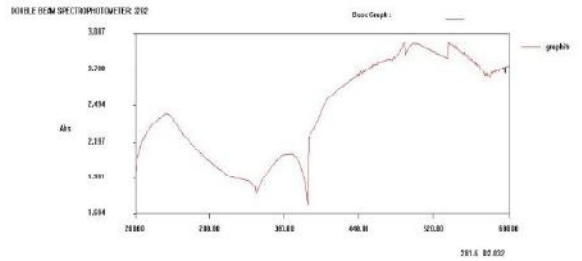


Figure 4.25: UV- Vis Spectroscopy for 0.2 vol graphite nanoparticles (<50nm) suspended in EG (3 hr sonication)

According to DLVO (Derjaguin, Verway, Landau and Overbeek) theory stability of dispersion of nanoparticles in fluids is resolute by the sum of van der Waals captivating forces & electrical double layer repulsive forces between nanoparticles when they come proximate to each other during the movement (Brownian motion) inside the fluid. If the captivating force is more immensely colossal than the repulsive force, the two particles that collide may adhere together and form aggregates with incremented size and may subside due to gravity, and making the unstable suspension. In the absence of the surface active agent, as a result of lack of electrostatic repulsion, van der Waals attraction. As the surfactant is added, growing repulsion from adsorbed surfactant causes the graphite nanoparticle aggregates to develop a more compact structure due to an increase in the particle to particle overlap area. In addition of critical surface active agent, it is found that the dispersed state becomes stabilized, and the kinetic barrier prevents the longer period aggregation.

CONCLUSIONS

Zeta potential tests are conducted for distilled water based Graphite nanofluids by varying the ultrasonic duration for < 50nm particle size of graphite nanoparticles.Zeta potential study for EG based graphite nanofluids prepared by ultrasonication (2-hour and 4-hour) for < 50nm particle size was carried out after preparation. EG based graphite nanofluids are prepared for two volume concentration (0.1% and 0.2%) by adding PVP as a surface agent. A UV-Vis Spectroscopy study was carried out after preparation by using a standard cuvette size. Results showed that stability depends on the ultrasonication duration for the test conducted within 2 to 3 hours of preparation of water based graphite nanofluids. A standard value of absorbing wave length is obtained for the Graphite nanoparticles dispersed in EG.

REFERENCES

[1] M. Hemmat Esfe, A. Karimipour, W.-M. Yan, M. Akbari, M. R. Safaei, and M. Dahari, "Experimental study on thermal conductivity of ethylene glycol based nanofluids containing Al2O3 nanoparticles," Int. J. Heat Mass Transf., vol. 88, pp. 728–734, 2015.

[2] H. M. Zaid, M. Adil, L. K. Chuan, and N. R. A. Latiff, "Stability and electrorheology of ZnO nanofluids in the presence of anionic surfactants," AIP Conf. Proc., vol. 1787, 2016.

[3] S. M. Ladjevardi, A. Asnaghi, P. S. Izadkhast, and A. H. Kashani, "Applicability of graphite nanofluids in direct solar energy absorption," Sol. Energy, vol. 94, no. August, pp. 327–334, 2013.

[4] D. K. Devendiran and V. A. Amirtham, "A review on preparation, characterization, properties and applications of nanofluids," Renew. Sustain. Energy Rev., vol. 60, pp. 21–40, 2016.

[5] T. V. R. Sekhar, "Characterization of Nanofluids-A Brief Overview," Int. J. Sci. Res. Dev., vol. 3, no. 7, pp. 238–241, 2015.

[6] H. Zhu, C. Zhang, Y. Tang, J. Wang, B. Ren, and Y. Yin, "Preparation and thermal conductivity of suspensions of graphite nanoparticles," Carbon N. Y., vol. 45, no. 1, pp. 226–228, 2007.

[7] S. M. S. Murshed, K. C. Leong, and C. Yang, "Enhanced thermal conductivity of TiO2 - Water based nanofluids," Int. J. Therm. Sci., vol. 44, no. 4, pp. 367–373, 2005.

[8] I. Tavman and a Turgut, "Experimental investigation of viscosity and thermal conductivity of suspensions containing nanosized ceramic particles," Arch. Mater. …, vol. 34, no. 2, pp. 99–104, 2008.

[9] [9] H. Chen, Y. Ding, and C. Tan., "Rheological behaviour of nanofluids," New J. Phys., vol. 9, p. 367, 2007.

[10] W. Duangthongsuk and S. Wongwises, "Measurement of temperature-dependent thermal conductivity and viscosity of TiO2-water nanofluids," Exp. Therm. Fluid Sci., vol. 33, no. 4, pp. 706–714, 2009.

[11] J. Jeong, C. Li, Y. Kwon, J. Lee, S. H. Kim, and R. Yun, "Particle shape effect on the viscosity and thermal conductivity of ZnO nanofluids," Int. J. Refrig., vol. 36, no. 8, pp. 2233–2241, 2013.

[12] K. Yapici, N. K. Cakmak, N. Ilhan, and Y. Uludag, "Rheological characterization of polyethylene glycol based TiO2 nanofluids," Korea Aust. Rheol. J., vol. 26, no. 4, pp. 1–9, 2014.

[13] M. Mehrali et al., "Preparation, characterization, viscosity, and thermal conductivity of nitrogen-doped graphene aqueous nanofluids," J. Mater. Sci., vol. 49, no. 20, pp. 7156–7171, 2014.

[14] N. A. Usri, W. H. Azmi, R. Mamat, K. A. Hamid, and G. Najafi, Thermal Conductivity Enhancement of Al2O3 Nanofluid in Ethylene Glycol and Water Mixture, vol. 79. Elsevier B.V., 2015.

[15] A. Afzal, Z. Ansari, A. Rimaz, and F. M. K. Ramis, "Parallelization Strategies for Computational Fluid Dynamics Software : State of the Art Review," Arch. Comput. Methods Eng., 2016.

[16] R. Pinto, A. Afzal, L. D'Souza, Z. Ansari, and A. D. Mohammed Samee, "Computational Fluid Dynamics in Turbomachinery: A Review of State of the Art," Arch. Comput. Methods Eng., pp. 1–13, 2016.

[17] R. N. Pinto, A. Afzal, I. M. Navaneeth, and M. K. Ramis, "Computational Analysis of flow in Turbines," in Proceedings of the International Conference on Inventive Computation Technologies, ICICT 2016, 2016, vol. 2016.

[18] A. Afzal, M. Samee A. D, A. Javad, A. Shafvan S, A. P V, and A. Kabeer K. M, "Heat transfer analysis of plain and dimpled tubes with different spacings," Heat Transf. Res., pp. 1–13, 2017.

[19] H. Li, L. Wang, Y. He, Y. Hu, J. Zhu, and B. Jiang, "Experimental investigation of thermal conductivity and viscosity of ethylene glycol based ZnO nanofluids," Appl. Therm. Eng., vol. 88, pp. 363–368, 2014.

[20] J. Buongiomo, D. C. Venerus, T. Mckrell, and R. Buongiorno, J. D., Venerus, C., Prabhat, N., McKrell, T., Townsend, J., Christianson, "A benchmark study on the thermal conductivity of nanofluids," J. Appl. Phys., vol. 106, p. 94312, 2009.

[21] M. Chandrasekar, S. Suresh, and A. Chandra Bose, "Experimental investigations and theoretical determination of thermal conductivity and viscosity of Al2O3/water nanofluid," Exp. Therm. Fluid Sci., vol. 34, no. 2, pp. 210–216, 2010.

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