JNROnline Journal
ISSN:2320-3358
ISSN:0972-5547

Journal of Natural Remedies
Vol. 21, No. 6, (2020)

STABILITY AND RHEOLOGICAL STUDY ON CARBON-BASED NANOFLUIDS

Huei Ruey Ong [1*] Baranitharan Ethiraj [2], Balakrishnaraja Rengaraju [3], Swathi Govindaraj[4], Ashwin Raj Suresh[4], Wan Mohd Eqhwan Iskandar[1], Md. Maksudur Rahman Khan[5], Muhammad Khairul Anuar Mohamed[6], Ridzuan Ramli[7], Shanmuga Sundari Ilangovan[4], Rengesh Balakrishnan[8] And Shanmugaprakash Muthusamy[9]

[1]Faculty of Engineering & Technology, DRB-HICOM University of Automotive Malaysia, Peramu Jaya Industrial Area, 26607 Pekan, Pahang, MALAYSIA
[2]Department of Biotechnology, Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, INDIA
[3]Department of Food technology, Bannari Amman Institute of Technology, Sathyamangalam
[4]Department of Biotechnology, Bannari Amman Institute of Technology, Sathyamangalam
[5]Faculty of Chemical and Process Engineering Technology, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang, MALAYSIA
[6]Centre for Mathematical Science, College of Computing & Applied Science, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Kuantan, Pahang, MALAYSIA
[7]Malaysian Palm Oil Board (MPOB), No. 6 Persiaran Institusi, Bandar Baru Bangi, 43000, Kajang, Selangor, MALAYSIA
[8]Department of Pharmaceutical Engineering, Mahendra Engineering College, Namakkal District, Tamilnadu
[9]Department of Biotechnology, Kumaraguru College of Technology, Coimbatore - 641035

***Abstract*—** In this study, an organic derived nanofluid has been developed from bio-origin resources. Carbon nanopowder (CNP) is obtained from derived rice husk and was prepared via a simple two-steps thermal process with minimum energy (low temperature and reaction time) using solar assisted plasma furnace. Nanofluids comprised of CNP and EG/water binary mixture has been prepared at various concentration such as 0.02 – 0.10 vol% of CNP. Flow curve of nanofluids showed that at minimum inclusion of CNP improved the stress of the fluid significantly. More to the addition, dynamic viscosity measure possesses that addition of CNP stabilized the properties of the fluid compared to virgin base fluid. Moreover, the stability results showed that the nanofluids stabilized starting from 1 week onwards as evidenced by UV-Visible spectrophotometer analysis. Furthermore, little to no precipitate noticed even after 8 weeks. This work offers greener approach for nanofluids which organic derived and environmentally friendly (very low percentage of nanoparticle, 0.02 vol%)

***Keywords*—** Carbon, Nano fluids, CNP, SEM, Nano particle

1. INTRODUCTION

[*] Corresponding Author

Nanofluid is a fluid formed by dispersing metallic or non-metallic nanoparticles in a liquid with a typical size of less than 100 nm. Nanofluids have drawn tremendous interest recently due to their greatly improved characteristics especially in thermal properties [1]. This is as an alternative to overcome the less efficient heat transfer of the conventional base fluid, which limits their application. The scientists tentatively and hypothetically worked in the early days to increase the thermal conductivity of base fluids such as ethylene, water, oil and others [2]. Over the past century, researchers have sought to overcome the restricted heat transfer capabilities of conventional heat transfer fluids, as mentioned earlier, by developing a new class of fluids that provide better cooling or heating efficiency for a variety of thermal systems [3]. In terms of stability, nanofluids become more stable compared to conventional fluids because of size effect and Brownian particle motion in the liquid. Ultrafine nanoparticles could probably assist the movement of the particles evenly in a microchannel without interference and minimizing the size of the heat transfer system [3]. The properties of nanofluids and future challenges have been reviewed [4] and is reported that there are still several factors that held up the growth of nanofluids such as a lack of good theoretical models of property, poor characterisation of suspensions, agreement between theoretical and experimental findings as well as lack of theoretical understanding of mechanisms [5].

There are many types of material-based nanofluids have been researched through the years and numerous articles regarding nanofluids have been published. Some of them are aluminium nitrides nanofluids [6], zinc oxide nanofluids [7], silicon dioxide nanofluids [8], and carbon nanotubes and nanofluids [9]. Carbon nanopowder (CNP) is widely recognized as the enhancement in supercapacitor applications. Developing new nanofluids from CNP would give a potential to enhance the characteristics of the base fluid. In addition, most nanofluid studies emphasize the technique of preparation of nanoparticles. To the best of our knowledge, rice husk derived CNP nanofluid has not been reported in previous studies. The CNP will be obtained from the rice husk and is prepared using chemical method. The physical properties such as rheology and stability of the nanofluid will be investigated.

2. MATERIALS AND METHOD

2.1 NANOPARTICLE PREPARATION

CNP is obtained from a nanosilica manufacturer based in Shah Alam, Selangor which produces nanosilica derived from rice husk. This nanopowder is a by-product of burning the rice husk. The CNP is further crushed into smaller sizes using a set of marble mortar.

2.2 NANOPARTICLE CHARACTERIZATION

The surface morphology of CNP was observed by SEM images were carried out at an accelerating voltage of 200 KV

2.3 NANOFLUID PREPARATION

The CNP are dispersed in the base fluid, in this case pure ethylene glycol. Pure ethylene glycol is used instead of binary mixture (ethylene glycol + water) to study the thermal properties of this nanofluid. It will then be soaked in ultrasonic bath for 60 minutes to get a clear fluid with no precipitate. The sample will be produced in varying concentration (vol%) with 0.02%, 0.04%, 0.06%, 0.08% and 0.10%. Another sample will be based on weekly period to study the stability of the nanofluids

2.4 NANOFLUIDS CHARACTERIZATION

Viscosity tests were carried out with the Anton Paar MCR 302 rheometer and the Peltier system coupled to the Phoenix 2 thermostat. This equipment enables viscosity measurement with relative standard uncertainty of 5%. The geometry of the 60 mm diameter and 1° double cone angle was used. The dynamic viscosity was determined at a constant temperature of 298.15 K in the shear rate range from 100 to 1000s-1. Measuring the geometry with the glass rings was isolated from the environment. The prepared nanofluids were further characterized using the SHIMADZU UV SPECTROPHOTOMETER UV – 1800 with different weeks (week 1 – week 7) of 0.02 vol% CNP nanofluids

3. RESULTS & DISCUSSION

3.1 CHARACTERIZATION OF CNP USING SEM

The morphology of CNP was visualized by SEM and presented in Figure 1. It can be seen that, the size of CNP is in the range of 50-100 nm with irregular shape

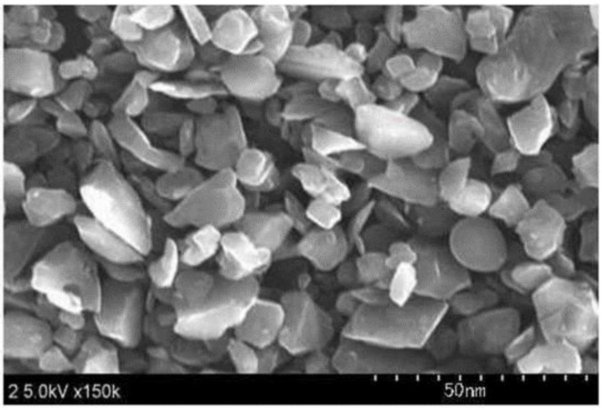

Fig. 1 SEM image for CNP

3.2 RHEOLOGICAL STUDY OF CNP NANOFLUIDS

A total of five samples were prepared from different concentration ranging from 0.02 vol% to 0.10 vol%. The nanoparticles were dispersed in the Ethylene Glycol and water (binary mixture). These samples are as shown in Figure 2

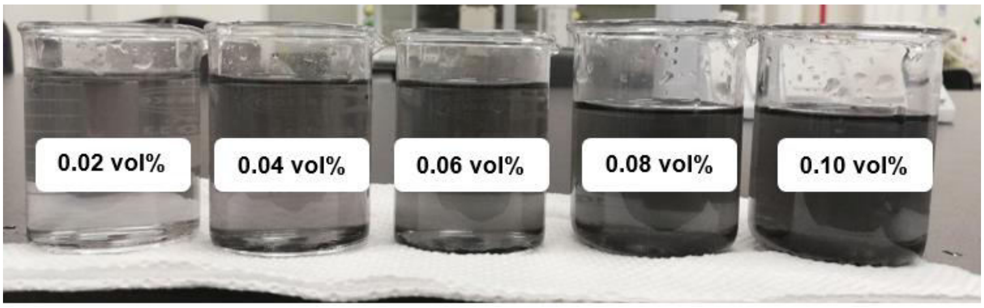

Fig. 2 Binary mixture with different concentration of CNP nanofluids

Figure 3a presents the flow curves of CNP in binary mixture nanofluids with variance volume fractions of particles at constant temperature 298.15K. It can be seen that with the shear rate, the shear stress improves linearly. The results also verify that binary mixture itself already shows the improvement of fluids and it is significantly increase with the addition of CNP with only a small portion which is 0.02 vol %. The higher the concentration of the CNP in the nanofluids, the higher the viscosity. Moreover, some of the nanofluids exhibit the similar pattern for example yttrium aluminium oxide [10], zinc oxide[11], cobalt oxide [12], copper oxide [13], and nanodiamonds[14].

Meanwhile, Figure 3b shows the dependence of viscosity against shear rate. The results show that the viscosity increases with increasing concentration of nanoparticles in the suspension. Thus, this will improve the properties of the base fluid. Similar patterns discovered for other nanofluids such as boron nitride [15], alumina nitride [16], Silicon carbide[17], alumina oxide [18], iron oxide [19], titanium dioxide [20] , tin oxide [21].

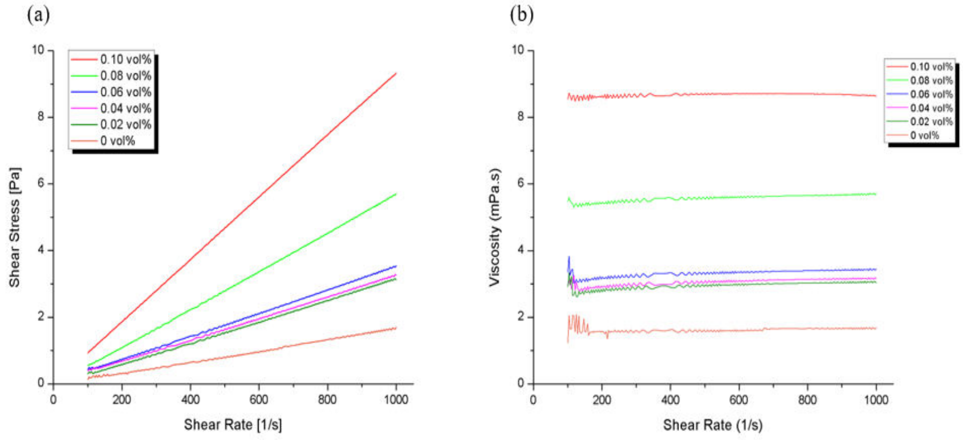

Figure 3 (a) Flow curve graph of different concentrations of CNP nanofluids, (b) Dynamic viscosity curves graph on various concentration of CNP nanofluids

3.3 STABILITY STUDY OF CNP NANOFLUIDS

The stability of nanoparticles is one of the most important characteristics for therapeutic applications. In this study, UV – Vis spectrum was used to evaluate the nanofluid stability. In order to study the stability of nanofluids on UV absorbency. The samples were tested from different duration starting from fresh sample to a seven week-aged sample and the data were recorded. From Figure 4, it can be seen that the peak of absorbance sits at the wavelength of 225 nm presenting the existence of CNP. This pattern is similar with spectrum as reported by Farbod, Ahangarpour [22]. Referring to Figure 5, the nanofluids peak is at range around 0.150 a.u. starting from 1 week-age onwards. This proven that CNP nanofluids becomes stable and improves the properties of the base fluids. Similar trends have been found through few research [23-25]. Small amount of nanoparticle (0.02 vol %) can boost up the properties of the base fluids [26-27]. Furthermore, there are no precipitation starting from the fresh sample until week 10.

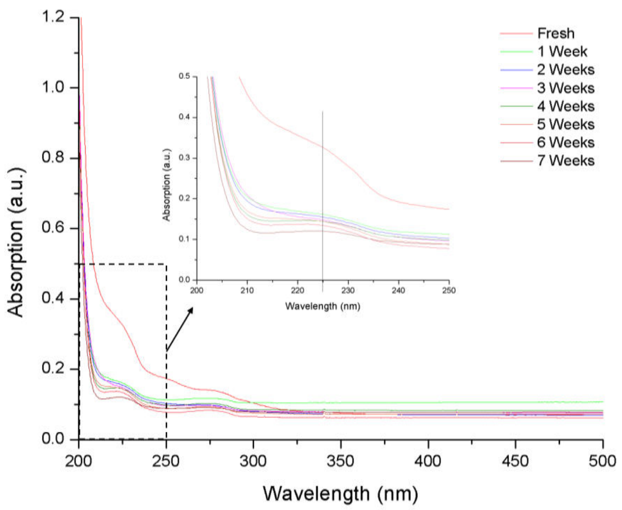

Fig. 4 Stability study of CNP nanofluids (UV-Visible measurement)

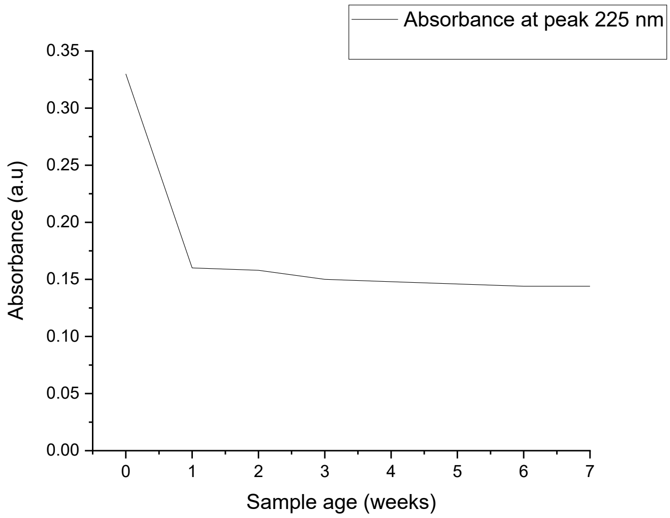

Fig. 5 Absorbance at peak 225 nm plotted for 8 weeks

4. CONCLUSION

CNP nanofluids was prepared through binary mixture EG/water and ultrasonication process with different concentrations from 0.02 vol% until 0.10 vol%. Characterization of CNP was discovered by SEM. Meanwhile, rheology and UV-Vis were used to characterize the performance of CNP nanofluids and nanofluids stability. The size of CNP were determine by SEM image ranging from 50nm-100nm with irregular shape. Experimentally, CNP–binary mixture improves the properties base fluid, in which the shear stress improves linearly respect to the shear rate with the addition of concentration CNP nanofluids. Moreover, dynamic viscosity curves graph shows the enhancement of CNP nanofluids when the viscosity is linear with increasing concentration of CNP nanofluids. The stability study using UV – Vis shows that the nanofluids stable within the duration of 8 weeks

REFERENCES

[1] Ghadimi, A., Rahman Saidur, and H. S. C. Metselaar. "A review of nanofluid stability properties and characterization in stationary conditions." International journal of heat and mass transfer 54.17-18 (2011): 4051-4068.

[2] Hayat, T., M. Ijaz Khan, M. Farooq, T. Yasmeen, and A. Alsaedi. "Water-carbon nanofluid flow with variable heat flux by a thin needle." Journal of Molecular Liquids 224 (2016): 786-791.

[3] Haddad, Zoubida, Chérifa Abid, Hakan F. Oztop, and Amina Mataoui "A review on how the researchers prepare their nanofluids." International Journal of Thermal Sciences 76 (2014): 168-189.

[4] Keblinski, Pawel, Jeffrey A. Eastman, and David G. Cahill. "Nanofluids for thermal transport." Materials today 8.6 (2005): 36-44.

[5] Devendiran, Dhinesh Kumar, and Valan Arasu Amirtham. "A review on preparation, characterization, properties and applications of nanofluids." Renewable and Sustainable Energy Reviews 60 (2016): 21-40.

[6] Hu, Peng, Wan-Liang Shan, Fei Yu, and Ze-Shao Chen. "Thermal conductivity of AlN–ethanol nanofluids." International Journal of Thermophysics 29.6 (2008): 1968-1973.

[7] Raykar, Vijay S., and Ashok K. Singh. "Thermal and rheological behavior of acetylacetone stabilized ZnO nanofluids." Thermochimica Acta 502.1-2 (2010): 60-65.

[8] Fazeli, Seyyed Abdolreza, Seyyed Mohammad Hosseini Hashemi, Hootan Zirakzadeh, and Mehdi Ashjaee. "Experimental and numerical investigation of heat transfer in a miniature heat sink utilizing silica nanofluid." Superlattices and Microstructures 51.2 (2012): 247-264.

[9] Hilding, Jenny, Eric A. Grulke, Z. George Zhang, and Fran Lockwood. "Dispersion of carbon nanotubes in liquids." Journal of dispersion science and technology 24.1 (2003): 1-41.

[10] Żyła, Gaweł. "Thermophysical properties of ethylene glycol based yttrium aluminum garnet (Y3Al5O12–EG) nanofluids." International Journal of Heat and Mass Transfer 92 (2016): 751-756.

[11] Pastoriza-Gallego, M. J., L. Lugo, D. Cabaleiro, J. L. Legido, and M. M. Piñeiro "Thermophysical profile of ethylene glycol-based ZnO nanofluids." The Journal of Chemical Thermodynamics 73 (2014): 23-30.

[12] Mariano, Alejandra, María José Pastoriza-Gallego, Luis Lugo, Lelia Mussari, and Manuel M. Piñeiro "Co3O4 ethylene glycol-based nanofluids: thermal conductivity, viscosity and high pressure density." International Journal of Heat and Mass Transfer 85 (2015): 54-60.
[13] Namburu, Praveen K., Devdatta P. Kulkarni, Debasmita Misra, and Debendra K. Das "Viscosity of copper oxide nanoparticles dispersed in ethylene glycol and water mixture." Experimental Thermal and Fluid Science 32.2 (2007): 397-402.
[14] Yu, Wei, Huaqing Xie, Yang Li, Lifei Chen, and Qiang Wang "Experimental investigation on the thermal transport properties of ethylene glycol based nanofluids containing low volume concentration diamond nanoparticles." Colloids and Surfaces A: Physicochemical and Engineering Aspects 380.1-3 (2011): 1-5.
[15] Żyła, Gawel, Adam Witek, and Magdalena Gizowska. "Rheological profile of boron nitride–ethylene glycol nanofluids." Journal of Applied Physics 117.1 (2015): 014302.
[16] Żyła, Gawel, and Jacek Fal. "Experimental studies on viscosity, thermal and electrical conductivity of aluminum nitride–ethylene glycol (AlN–EG) nanofluids." Thermochimica Acta 637 (2016): 11-16.
[17] Li, Xiaoke, Changjun Zou, Taiyang Wang, and Xinyu Lei. "Rheological behavior of ethylene glycol-based SiC nanofluids." International journal of heat and mass transfer 84 (2015): 925-930.
[18] Żyła, G., J. Fal, M. Gizowska, A. Witek, and M. Cholewa. "Dynamic Viscosity of Aluminum Oxide-Ethylene Glycol (Al 2 O 3-EG) Nanofluids." Acta Physica Polonica, A. 128.2 (2015).
[19] Pastoriza-Gallego, María Jose, Luis Lugo, José Luis Legido, and Manuel M. Piñeiro. "Rheological non-Newtonian behaviour of ethylene glycol-based Fe 2 O 3 nanofluids." Nanoscale research letters 6.1 (2011): 560.
[20] Cabaleiro, David, María J. Pastoriza-Gallego, Carlos Gracia-Fernández, Manuel M. Piñeiro, and Luis Lugo "Rheological and volumetric properties of TiO 2-ethylene glycol nanofluids." Nanoscale Research Letters 8.1 (2013): 286.
[21] Mariano, Alejandra, María José Pastoriza-Gallego, Luis Lugo, Alberto Camacho, Salvador Canzonieri, and Manuel M. Piñeiro "Thermal conductivity, rheological behaviour and density of non-Newtonian ethylene glycol-based SnO2 nanofluids." Fluid phase equilibria 337 (2013): 119-124.
[22] Farbod, Mansoor, Ameneh Ahangarpour, and Seyed Gholamreza Etemad. "Stability and thermal conductivity of water-based carbon nanotube nanofluids." Particuology 22 (2015): 59-65.
[23] Sadeghi, R., S. Gh Etemad, E. Keshavarzi, and M. Haghshenasfard "Investigation of alumina nanofluid stability by UV–vis spectrum." Microfluidics and Nanofluidics 18.5-6 (2015): 1023-1030.
[24] Ghadimi, A., Rahman Saidur, and H. S. C. Metselaar. "A review of nanofluid stability properties and characterization in stationary conditions." International journal of heat and mass transfer 54.17-18 (2011): 4051-4068.
[25] Haiss, Wolfgang, Nguyen TK Thanh, Jenny Aveyard, and David G. Fernig. "Determination of size and concentration of gold nanoparticles from UV− Vis spectra." Analytical chemistry 79.11 (2007): 4215-4221.
[26] Dhanalakshmi, R. "To Study and Survey About Load Frequency Control for Stability Improvement of Power System With Excitation Control." International Journal of MC Square Scientific Research 2.1 (2010): 13-18.
[27] JayaKumar, R. "FABRICATION OF HTC PLANT FOR CARBONISATION OF INDUSTRIAL WASTE." International Journal of MC Square Scientific Research 9.1 (2017): 10-17.