Synthesize and Characterization of *Aluminum Oxide* (Al_2O_3) Nanoparticle from Aluminum Waste for Nano fluid Application

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Abstract. The research of Synthesis and Characterization of Aluminum Oxide (Al_2O_3) Nanoparticle from Aluminum Waste for Nanofluids has been done. The purpose from this research are knowing the influence of heating temperature to nanoparticle Al_2O_3 forming and the influence of composition to physico-chemical characteristic of nanofluids Al_2O_3.The heating temperature variation that that use of 600^0C, 700^0C, and 800^0C. While the composition variation that use of 0.1 gram, 0.2 gram, 0.3 gram, and 0.5 gram. Aluminium Oxide nanoparticle were synthesized by heating $Al(OH)_3$ as precursor derived from aluminum waste precipitation. Aluminum Oxide nanoparticle were suspended with 100 ml of Aquades and dispersed with ultra sonicated to produce Al_2O_3 nanofluids. Al_2O_3 nanoparticle has been obtained doing the characterization are the test of XRD (X-Ray Diffraction), SAA (Surface Area Analyzer), Density, Viscosity, CHF (Critical Heat Flux) and Zeta Potential. XRD data showed that the crystallized peak from Al_2O_3 nanoparticle are gamma alumina with the crystallite size of 6,5 nm (Debye-Scherrer Method). The Surface Area test result from Al_2O_3 nanoparticle is 149,98 m^2/gram and obtained shape of11 nm. According zeta potential data, Nano fluids were stable at pH of 6,3 with zeta potential of 36,70 - 43,53 mV. The density test result obtained with the highest value about 1,503 g/cm^3, The viscosity test of 0.92 mPa.s at the composition variation of 0.5 gram. The Nano fluids of the surface decreased 40% after 7 days. CHF test result of Al_2O_3 nanofluids obtained enhancement about 53,21% at the composition variation of 0.5 gram compared to that of Aquades.

INTRODUCTION

The development and sophistication of technology that is so fast in the current era of globalization are supported by natural resources that are very adequate and have the potential to be used so that they are able to support the fulfillment of human needs in various fields, one of which is in the industrial sector related to heat transfer systems. In the heat transfer system, especially in the industrial sector, it is very important related to the cooling performance which is determined by thermal conductivity. Low thermal conductivity is a major limitation in the industrial sector so that many losses are caused due to lack of attention to system performance efficiency. So it is necessary to have a technique and method that can save energy and increase the efficiency of system performance.

Most industrial fields today still use conventional fluids such as water, engine oil, ethylene glycol as a fluid for heat transfer. The utilization of conventional fluids actually hinders the performance of the system, one of which is that the engine quickly gets hot and within a certain period of time it will damage the engine so that to reduce the weaknesses caused by the use of conventional fluids, a new fluid known as nanofluid is needed.

Nanofluid is a material consisting of a solid material measuring between 1-100 nanometers dispersed in a solvent / liquid. The most important criterion in a nanofluid is the stability of the particles as seen from the level of agglomeration / agglomeration without causing chemical changes. The kinds of nanofluids that have been studied currently include nanofluid-alumina, nanofluid-zirconia, and nanofluid-hematite. The uniqueness of nanofluids affects the physical quantities possessed by nanofluids, including density, viscosity, Critical Heat Flux

(CHF), and thermal conductivity (Veeranna and Lakshmi, 2011). This physical quantity is an important basic parameter in the heat transfer system. One of the nanofluids that can be used as heat transfer is a nanofluid based on Aluminum Oxide (Al_2O_3). powder. Aluminum Oxide (Al_2O_3) is widely used as a refractory material. This is because Aluminum Oxide (Al_2O_3) has various features, namely it has good corrosion resistance in various environments, has excellent bioinert properties and has high temperature resistance and good electrical resistance.

In this case,to increase valuable aspect and more economic, we employ aluminum waste as raw material. Aluminum Oxide nanofluid to be synthesized will be obtained from (Al_2O_3) nanoparticles from aluminum waste. Characterization of the physico-chemical properties of (Al_2O_3) nanofluids includes density test, fluid viscosity test, Critical Heat Flux (CHF) test, and particle stability test and zeta potential test.

EXPERIMENTAL METHOD

Synthesize Al_2O_3 nanoparticle

Aluminum waste and NaOH with a mole ratio of 1: 4 are mixed with a dissolving and stirring process until homogeneous. After that the residue is separated through a filtering process to obtain the sodium aluminate filtrate. Then the sodium aluminate that has been obtained is carried out a precipitation process with the addition of HCl. The precipitate obtained is then washed using Aquades. The results of the washing were heated at 100^0C to obtain $Al(OH)_3$.

$Al(OH)_3$ that has been obtained is then heated at 600^0C, 700^0C, and 800^0C for 3 hours to obtain Al_2O_3 nanoparticles. The Al_2O_3 nanoparticles were then characterized using XRD to determine the phase formed and the crystal size (Debye-Scherrer method). The Surface Area of Al_2O_3 nanoparticles was measured using the Surface Area Meter of Quantachrome NOVA 2200.

Synthesize Al_2O_3 Nanofluida

Al_2O_3 nanoparticles with a composition of 0.1, 0.2, 0.3, and 0.5 grams were then suspended in 100 ml of Aquades and homogenized using an ultrasonic bath for 2 hours to obtain the nanofluid and let stand for 24 hours. After the calculation, the concentration of nanofluids was obtained for 0.035, 0.045, 0.050, and 0.083% vol. Visually, observations are made every day to determine the level of stability of the particles. The Al_2O_3 nanofluid was then carried out by characterization in the form of density using the Mohr balance tool, the viscosity of the fluid was measured using the Vibro Viscometer SV-10, the Zeta potential using the Malvren Zetasizer System, and CHF using the method found by Lee, et al., Hiswankar, and Kshirsagar with copper wire. with a diameter of 0.2 mm.

RESULT AND DISCUSSION

The visual appearance of the Al_2O_3 nanoparticles is shown in Figure 1 and the XRD results are shown in Figure 1.

FIGURE 1. The visual appearance of the Al_2O_3 nanoparticles

From Figure 2 it is shown that the crystalline phase formed from the nanoparticles is in the gamma alumina phase. The peak formed from the XRD test results showed that the crystal size obtained was 6.5 nm using the Debye-Schrrer method. The Specific Surface Area of the Al_2O_3 nanoparticles is 149,98 m^2/g. When the size of the Al_2O_3 nanoparticles is estimated from the Specific Surface Area value using equation 1, a particle size of 11 nm will be obtained. This value is almost close to the results of the calculation of the XRD characterization results using the Debye-Scherrer method. This is due to the agglomeration of the nanoparticles.

$$d = \frac{6000}{\rho . A_s} \qquad (1)$$

where d = particle size (nm), ρ = the theoretical density of nanoparticles (g/cm^3), and A_s = Specific Surface Area.

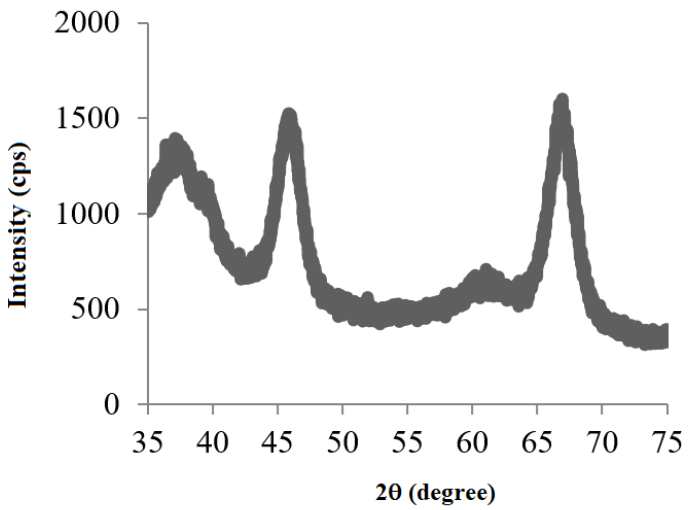

FIGURE 2. XRD pattern of Al_2O_3 nanoparticle

Nanofluids with a concentration of 0.0832 vol% were used for observations from time to time in determining particle stability. The quantitative decrease in the particle stability of the surface height of the nanofluids is shown in Figure 3. The surface height of the nanofluids decreased by 40% from the initial height after 7 days of observation.

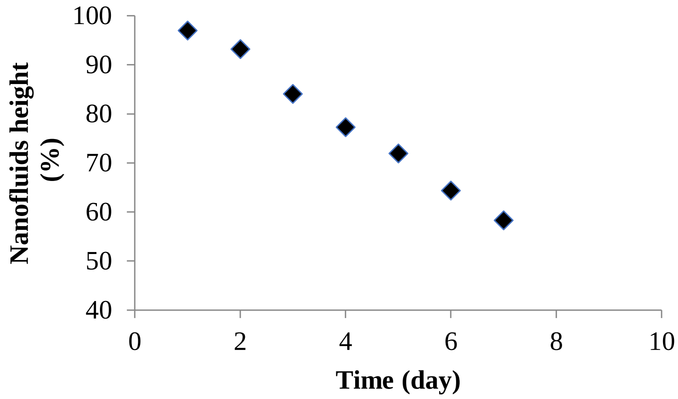

FIGURE 3. The relation graph of Al_2O_3 Nano fluid surface height against time observation with Al_2O_3 0.0832 % Vol and pH 6.091

The results of zeta potential measurements of Al_2O_3 nanofluids are shown in Figure 4. This shows that the zeta potential changes relative to changes in the concentration of Al_2O_3 nanofluids. Nanofluids are stable when the zeta potential is greater than 30 mV or less than 30 mV. From these results that the nanofluid is stable at a pH between 6.0 - 6.3.

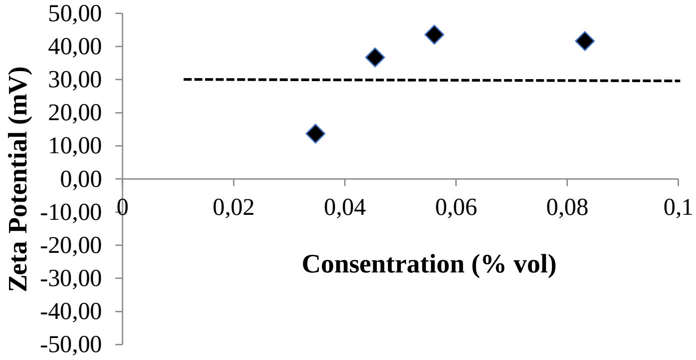

FIGURE 4. Zeta potential of Al_2O_3 nanofluid

The viscosity data of the Al_2O_3 nanofluid is shown in Figure 5. The viscosity of the Al_2O_3 nanofluid increases with increasing concentration of the Al_2O_3 nanoparticles. Compared to Einstein's predictions, the increment gradient of the viscosity value is larger. This shows that the presence of suspended nanoparticles in the basic solvent will increase the viscosity value significantly, which does not follow Einstein's predictions. So this is a review of nanofluids that does not only refer to mixing nanoparticles with solvents.

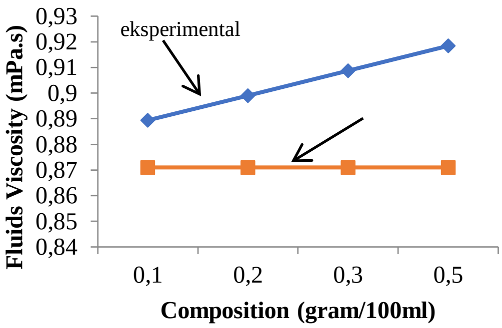

FIGURE 5. The viscosity graph of Al_2O_3 nanofluid

Data on the density of Al_2O_3 nanofluids is shown in Figure 6. The viscosity of Al_2O_3 nanofluids increases with increasing concentrations of Al_2O_3 nanoparticles. Compared to the correlation of the Pak and Cho equations, the increment gradient of the density values is quite large. This shows that the presence of Al_2O_3 nanoparticles suspended in the basic solvent will increase the density value of the particles in the nanofluid (assuming a fixed volume) so that the density increase is quite significant which does not follow the correlation equation from Pak and Cho.

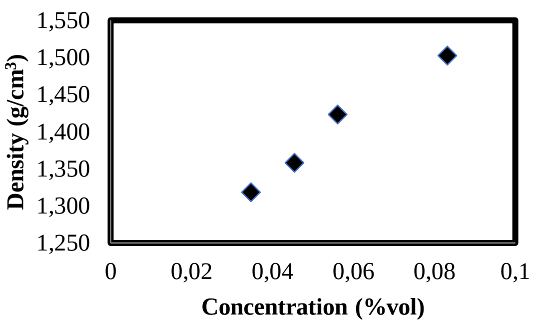

FIGURE 6. The density graph of Al_2O_3 nanofluid

Data on the increase in CHF as a function of the concentration of Al_2O_3nanofluids are shown in Figure 7. The increase in CHF increases linearly with the addition of the concentration of Al_2O_3 nanoparticles from 14% to 53%. This shows that the heat transfer from the copper wire to the nanofluid goes well with the increase in the concentration of nanoparticles. The mechanism for the increase in CHF in nanofluids is caused by particles of the nanofluid which envelop the surface of the copper wire.

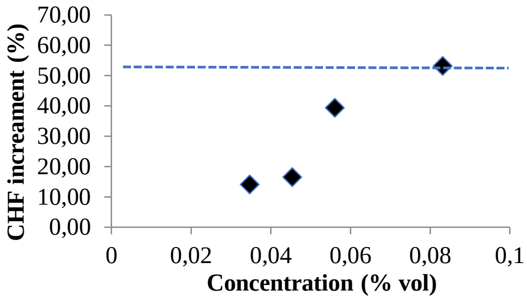

FIGURE 7. The increasing CHF graph of Al_2O_3 nanofluid as nanoparticle concentration function

CONCLUSION

Berdasarkan hasil dan pembahasan bahwa nanopartikel Al_2O_3 dengan ukuran kristal sebesar 6,5 nm telah disintesis dengan menggunakan metode presipitasi dari $Al(OH)_3$ yang diperoleh dari limbah aluminium melalui proses kalsinasi. Nanofluida memiliki kestabilam pada pH 6,0 – 6,3. Kenaikan CHF dari nanofluida sebesar 14-53% dibandingkan dengan nilai CHF *Aquades* dengan konsentrasi Al_2O_3 sebesar 0.035-0.083 %vol.

Based on the results and discussion, Al_2O_3 nanoparticles with a crystal size of 6.5 nm have been synthesized using the precipitation method of $Al(OH)_3$ obtained from aluminum waste through the calcination process. Nanofluid has stability at pH 6.0 - 6.3. The increase in CHF from the nanofluid was 14-53% compared to the CHF value of Aquades with a concentration of Al_2O_3 of 0.035-0.083% vol.

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