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An experimental study on the dispersion and stability of (CNT/Alumina) nanofluid

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Abstract- In recent years, nanofluids technology is proposed and studied due to their novel properties which make them potentially useful in many applications in heat transfer. Good dispersion of nanoparticles in the base fluid, which have been designated "nanofluid", exhibits enhanced thermal conductivity and higher heat transfer coefficient. The present study aimed to evaluate a simple, efficient approach to improve the dispersion of MWCNTs and Alumina particle aqueous media for preparing the hybrid nanofluid. Samples were prepared with a different mass ratio of CNT and Alumina nanoparticles (2:1; 1:1; 1:2) and two dispersion techniques were tested. Planetary Ball Milling performed for the CNT structure as a mechanical method to reduce the agglomerated size of particles and greatly enlarge the surface area of the CNT. Plus, cellulose material was used for the better solution. Dispersion quality of the hybrid nanofluids examined by UV-Vis spectroscopy. The experimental result showed the sample that was treated by mechanical and dispersant methods is the effective way for the dispersibility of the composite nanofluid along with stability.
Keywords – Dispersion, Hybrid nanofluid, MWCNTs, Cellulose Nano Crystal, Planetary Ball Milling

I. INTRODUCTION

Nanofluids have been studied for the last decade with the huge potential to enhance the efficiency of the heat transfer characteristics [1-3]. Therefore, well-dispersed nanoparticles for nanofluids are very expected to improve mechanical performance through many industry [4-5]. Not surprisingly, CNTs dispersion homogeneity is indispensable for the further application of nanofluids. So, well-dispersed CNTs suspensions are one of most sought-after endeavors in the field of nanocomposite materials. To overcome dispersion issues, different approaches based on chemical and mechanical processes have been proposed and evaluated [6-7]. Some studies have been conducted on the improvement of dispersion. Munkhbayar et al. [8] reported a planetary ball milling method that are applied to enhance the dispersibility of nanoparticles in a base fluid distilled water. When CNC used as dispersion agent, CNT nanoparticle dispersed well in aqueous media. Due to the effect of the oppositely charged ions on the surface of the CNT and CNC, an interaction occurs which results in stable dispersion. [9] AciQinzhi Lia et al. [10] studied dispersion of nano-cellulose function of salinity and storage time. The cellulose nanocrystals (CNC) have become widespread in the many research [11-14]. It has rod-shaped nanoparticles obtained from the acid hydrolysis of cellulose. It is about from 10 to 100 nm in diameter and from 100 nm to 1000 nm in length, depending on the cellulose source and the hydrolysis conditions. CNC interact with water strongly through hydrogen bonding due to the hydroxyl groups on the cellulose molecule. In this study, the mechanical and chemical process were investigated to obtain well-dispersed hybrid nanofluids.

II. EXPERIMENTAL DETAILS

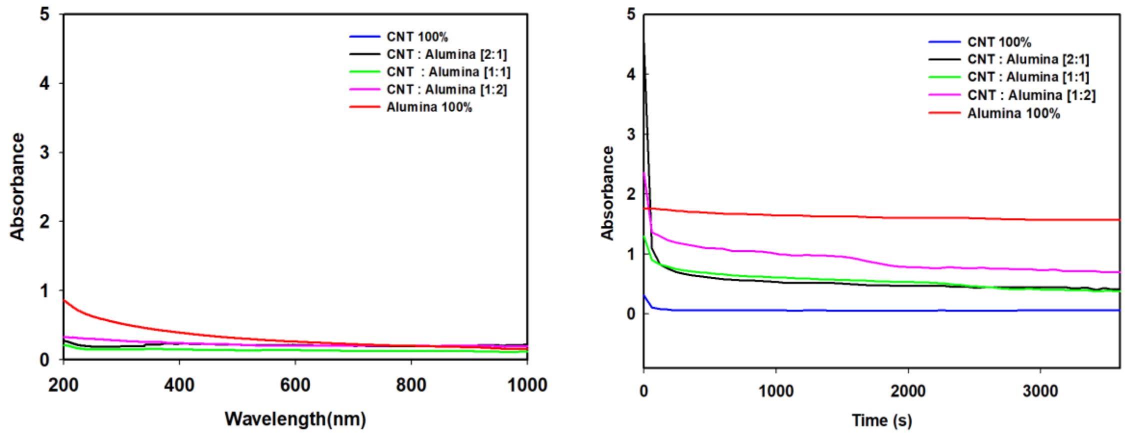
The MWCNTs and Alumina hybrid nanofluid were prepared with different ratio of CNT and Alumina (2:1; 1:1; 1:2) and two dispersion techniques were tested by Planetary Ball Milling and chemical and adding the dispersant for the nanofluid. MWCNTs nanoparticles were dispersed in aqueous using an ultrasonic bath (1510E- DTH Branson Ultrasonic Corporation, USA) for 2 hours.

Wet grinding operations performed by planetary ball milling (HPM- 700, Haji Engineering, Korea) was used to shorten the length of the nanoparticles by the wet grinding process. In this study, Mono-sized (3.0 mm) spherical Zirconia (ZrO_2) balls were used as the collision medium. The agitator -applied rotation speed was 500 rpm and the wet grinding process was 1 hour before the ultrasonication. The detailed process of this have been introduced in the previous research [8].

To make the better dispersion, CNC added to the ground MWCNTs as a dispersant. For both cases, samples were prepared with a different ratio of CNT and Alumina (2:1; 1:1; 1:2), the dispersion characteristic of CNT/Alumina hybrid nanofluid were examined with UV-Vis spectroscopy(xma 3100 spectrophotometer).

III. EXPERIMENT AND RESULT

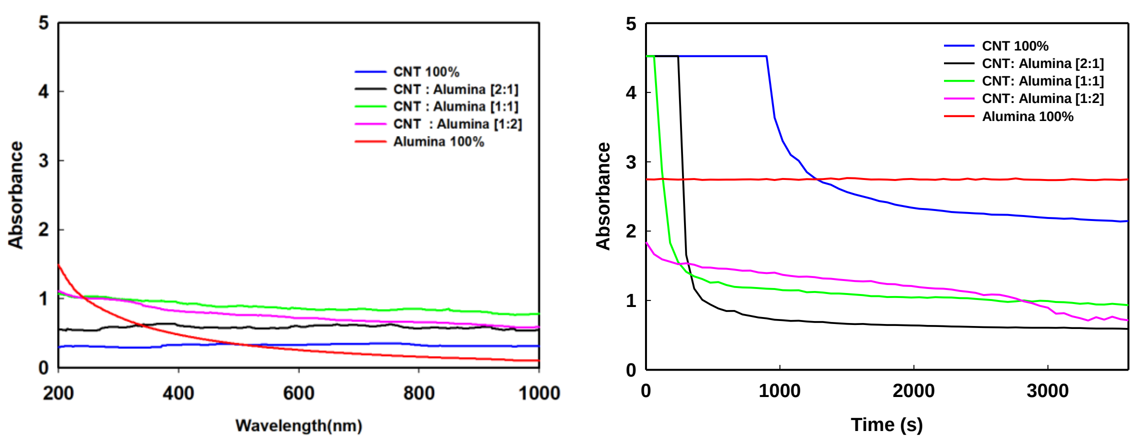
Obtained results from UV/Vis measurement are presented in the Figures 1-4 which shows the dispersion characteristics and a variation of absorbance prepared nanofluids function as time.



(a) (b)

Figure 1. UV/Vis measurement on CNT/Alumina hybrid nanofluid in aqueous with a different mass ratio of nanoparticles (2:1; 1:1; 1:2); a. wavelength b. as a function of time

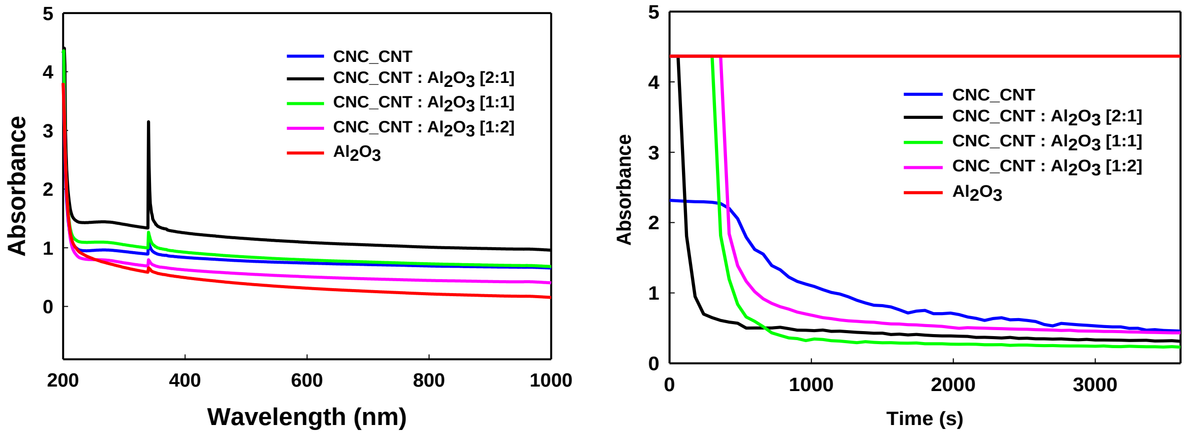
As shown in the Figure 1 (a), Alumina nanofluid exhibit the best dispersion characteristic as compared to the hybrid nanofluids. Pristine CNT/ Alumina hydrid nanofluids were (2:1; 1:1; 1:2) showed similar dispersibility. The dispersion stability of the nanofluid can be evaluated by UV/VIS absorbance measurement function with time (Figure 1b). Stability evaluation of the as-prepared nanofluids shown in figure 1b. Among the nanofluids, Pristine CNT/Alumina (1:2) has shown higher absorbance intensity than other. And all hydrid nanofluids was showing similar trends for maintained stability during the measuring time.



(a) (b)

Figure 2. UV/Vis measurement on Ground-CNT/Alumina hybrid nanofluid in aqueous with a different mass ratio of nanoparticles (2:1; 1:1; 1:2); a. wavelength b. as a function of time

The effect of the grinding process on dispersibility was designated by the comparison of the absorbance measurements Figure 1a and 2a. Due to the grinding process on CNT structure, dispersion ability of the CNT in aqueous media improved significantly along with the specific surface area. Moreover, dispersibility of the all hydrid nanofluid was increased as well (Figure 2a). In figure 2 (b) it can be clearly seen that absorbance value of the ground-CNT/Alumina nanofluids had increased significantly and the stability of the nanofluids remained for the long time as compared to the previous result shown in Figure1b. The result was confirmed that grinding process has considerable effect on the dispersion characteristics.



(a) (b)

Figure 3. UV/Vis measurement on CNT/Alumina hybrid nanofluid
in aqueous with a different mass ratio of nanoparticles (2:1; 1:1; 1:2) with (CNC);
a. wavelength b. as a function of time

Figure 3a, b showed that dispersion characteristics of the as-prepared hybrid nanofluid composited by CNT/ Alumina nanoparticles with different mass ratios of 2:1; 1:1; 1:2 with CNC. Absorbance peak intensity of the CNT was enhanced in aqueous due to the addition of the dispersant than others. Due to the improved dispersibility of the CNTs, dispersibility of the hybrid nanofluid increased greatly (Figure 3a). According to the previous measurement results (Figure 1b, 2b), it was found that mechanical grinding process was more effective than CNC (Figure 3b) for the CNT nanofluid.

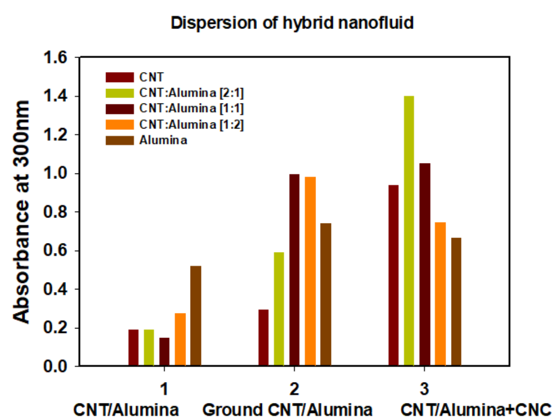


Figure 4. Absorbance values of CNT/Alumina hybrid nanofluids at the wavelength of 300 nm (just ultrasonicated)

From the UV/vis measurement results, the comparison of the absorbance peak values was shown in figure 4. Absorb ance peak intensity of the Pristine CNT/ Alumina hybrid nanofluid (1) is lower than other hybrid nanofluids. Howev er, the ground CNT/Alumina nanofluid (2) is improved. A significant improvement obtained for the chemically modified CNT/Alumina nanofluids (3).

It is evident from Fig. 2 the dispersion characteristics of CNT/Alumina nanofluid improved with the wet grinding pr ocess by PBM, even though, the stability of nanofluid did not maintain for long. Instead, dispersion process of hybri d with a dispersant was shown to be effective (Fig 3a, b). The dispersion characteristics of hybrid nanofluid (shown i n Fig 3a, b) has proved that CNC addition enhanced stability with an increase in alumina ratio.

IV.CONCLUSION

The present study concentrates on the development of dispersion techniques of CNT Alumina hybrid nanofluid in aqueous. Therefore, the main objective focused to determine a more acceptable way to increase dispersion characteristic of hybrid nanofluid without any surfactant. In conclusion, we have studied the dispersion and stabilization of as-prepared CNT/Alumina hybrid nanofluid in aqueous. For the overall result, the wet grinding process is more effective for dispersion of CNT nanofluid as compared other hybrid nanofluids. Instead, dispersion process of hybrid nanofluid stability with the dispersant (CNC) is shown to be efficient.

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