



Study the Effect of Gum Arabic and Triton X-100 on Stability and Thermal Conductivity of ZnO/ethylene glycol Nanofluids

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Abstract: *Stability of nanofluids is one of the most important factors to ensure the most benefit of the properties of nanoparticles. Zinc oxide was used in the research with concentration between (0.2-1) wt. % with ethylene glycol base fluid. The stability of ZnO nanofluid was enhanced by adding two types of surfactants Tx-100 and Gum Arabic with concentration of (0.1-0.5) vol. % to stabilize the ZnO nanoparticles in the base fluid. The results showed that the Gum Arabic surfactant led to more stable fluid than that of Tx-100; this was shown from zeta potential and UV spectroscopy measurements. The thermal conductivity coefficient was also measured, and the results showed that the thermal conductivity increased with adding surfactant than without using a stabilizer.*

Keywords: *ZnO/ethylene glycol nanofluids, stability, Tx-100 surfactant, Gum Arabic, thermal conductivity*

1. Introduction

Energy can be saved in different ways engineering operations. The need to enhance heat transfer of fluids has led the use of solid particles suspension as one of the most important methods because of their high thermal conductivity. However, these particles have few behavior problems such as sedimentation, fouling and pressure drop increment. There are many techniques used to overcome them and to increase the stability of these particles in many different base fluids. Different materials are used as solid particles suspended into the fluids, like metals (Al, Cu, Au, Fe, etc), oxides (Al₂O₃, TiO₂, CuO, SiO₂, Fe₂O₃), and different chemical compounds (AIN, CaCO₃, SiC, graphene, etc). These particles are suspended in traditional solvents fluid like water, ethylene glycol, engine oil, propylene glycol and more. The nanoparticles need to have a large surface area, but the flow of such suspension through a narrowed channel (constricted channel) may become intermittent and may led even to clogging. Therefore, the nanofluid must be able to avoid this in the flowing and to increase thermal conductivity. Two – step method included the suspension of nanoparticles into the base fluids by employing various mechanical, physical and chemical mechanisms. Xie et al. [1] used such two-step methods to prepare Al₂O₃ with propylene glycol and ethylene glycol base fluids. The TiO₂/water nanofluid was prepared by Murshed et al. [2]. The advantage of the method used to prepare nanofluids is that the nanoparticles have the ability to agglomerate during time due to high surface activity. Many studies were focused to about the different ways to increase the stability of nanofluids, including finding the optimum pH range, dispersal materials, and surfactants, shear mixing and ultra-sonic agitation. Different studies confirmed that the changing of pH meter or using different concentration to each the dispersants and nanoparticles in the base fluids. This is indicated to enhance the stability of nanofluids, which also affected to their property like, thermal conductivity and viscosity [3–8]. Hwang et al. [9] have used two types of nanoparticles carbon black and silver, suspended in water and silicon- oil base fluid respectively. By adding SDS (Sodium Dodecyl Sulfate) as a surfactant with 1 wt. % concentration, these prepared nanofluids showed

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the stability during 60 days. The semiconductor materials with great advantages were employed in many applications in optoelectronic devices, photo catalysts, cosmetics, pigments, ceramics, solar cells and sensors [10, 11]. Chaudhuri and Paria [12] used sulfur nanoparticles in base fluid and added different surfactants to analyze the suspension stability. Other authors [13] applied UV- visible spectroscopy to study to study the stability of TiO₂ nanoparticles in base fluid with different surfactants. Zaid et al. [14] investigated the effect of SDS surfactant on recovered oil with two types of nanoparticles ZnO and Al₂O₃. Also, we mention the researches of Anand and Siby [15] about the effect of four different surfactants (Triton Tx-100, polyethylene glycol (PEG 6000), cetyltrimethylammonium bromide (CTAB), SDS) added into a zinc oxide / water base fluid. Irwan et al. [16] have used Gum Arabic as surfactant to study the stability of Al₂O₃/ water nanofluid.

2. Materials and methods

2.1. Materials

Zinc oxide nanoparticles (Aladdin Reagents Company, Shanghai, Chania) are used in this paper. There are two types of surfactants is added into nanofluids Tx-100 (Beijing GH Trading Co., ltd.) and Gum Arabic (Guangzhou Zio Chemical Co., ltd.) with ethylene glycol as solvent.

2.2. Preparation of Nanofluid

Zinc oxide nanoparticles are in the form of white powder with particle sizes of 5 nm. The ZnO nanoparticles are added to the ethylene glycol base fluid at different weight fraction (0.2-1) wt. %. The surfactant is added into the ZnO/ethylene glycol at different concentration (0.1-0.5) vol. %. The nanofluids prepared by mixing the solid nanoparticles with ethylene glycol using 400 rpm stirring. Then the nanofluids are stabilized by sonication (MTI Corporation made in USA, equipment) for 30 min to obtain a good stability of nanofluid prepared.

2.3. Characterization Measurements

Zeta potential of ZnO/ethylene glycol without/with surfactant nanofluids was determined by using equipment (Zeta plus USA made). UV-vis spectrometer type (Shimadzu UV-160) and a thermal property analyzer KD2 Pro (Decagon Device Corp., Pullman) were also used to measure the light absorbance and thermal conductivity, respectively. All the characterization measurements were performed at room temperature.

3. Results and discussions

3.1. Zeta potential

Measuring the zeta potential of nanofluids with two types of surfactants Tx-100 and Gum Arabic (GA) is one of the most important method to study the mechanism of stability of ZnO/ ethylene glycol nanofluid. The zeta potential is measured during 60 days for different concentrations between (0.1- 0.5) wt. % for Tx-100 and Arabic Gum. Figure 1 shows the stability (expressed by values of zeta potential) of ZnO/ ethylene glycol nanofluids without stabilizer. The results reveal that the nanofluid with less concentration of stability of ZnO is much more stable than the samples with high concentration of ZnO in the base fluid. This is happened due to the mechanism of Brownian motion at high concentration the when the ZnO nanoparticles tend to agglomerate and they are settled after short time, in agreement with Irwan et al. [16].

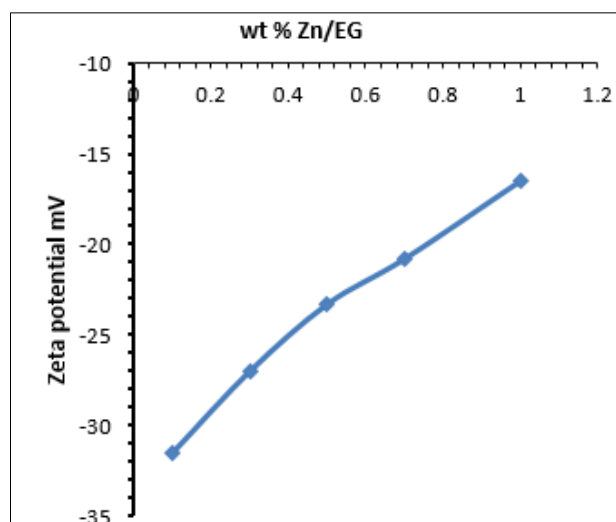


Figure 1. Zeta potential values ZnO/ ethylene glycol nanofluids without surfactants at different concentrations

Figure 2 shows that values of zeta potential at different surfactants concentrations (0.1-0.5) wt. %. The obtained values are in the range of -30 to -40 mV for Tx-100 and in the range of -48 to -55 mV for GA. It is known that nanofluids are considered stable if the zeta potential ranges between (40-60) mV (either negative or positive values). Our results show therefore a higher stability for mixture with Gum Arabic (GA) than with Tx-100 for the same concentrations. We interpreted the fact that the Gum Arabic leads to a higher stability than Tx gum because of its ability to minimize the interactions between ZnO nanoparticles, as also stated by Pauzi et al. [17].

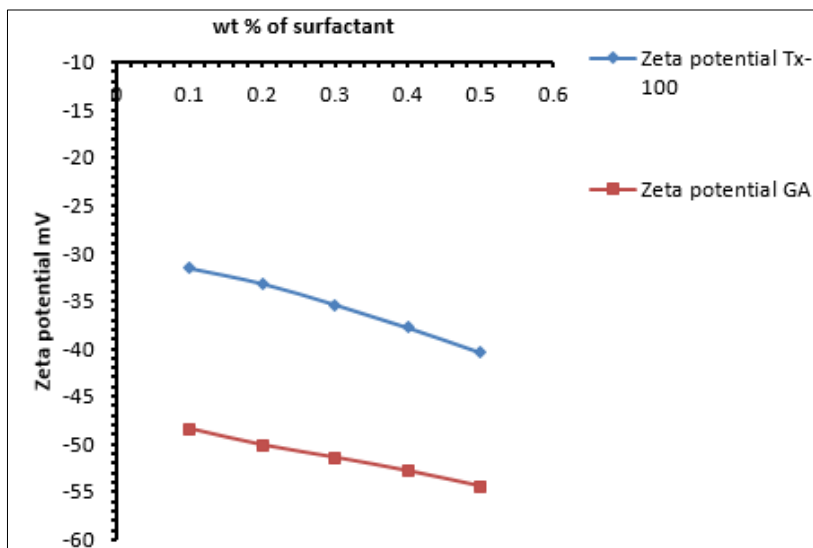


Figure 2. Zeta potential values of ZnO containing nanofluids with Gum Arabic and Tx-100 addition for different concentrations

3.2. UV-Vis spectrophotometry

The stability of prepared nanofluids ZnO/ ethylene glycol containing surfactants can also be simply illustrated by the absorbance of light using UV-Vis spectrophotometry just after their preparation. Figure 3 shows that the wavelength of absorption peaks for just prepared ZnO/ethylene glycol with GA and Tx at constant concentration of 0.5 vol.% is 370 nm and 335 nm, respectively, this being in agreement with the standard value of ZnO nanofluids as reported by Estrada-Urbina et al. [18].

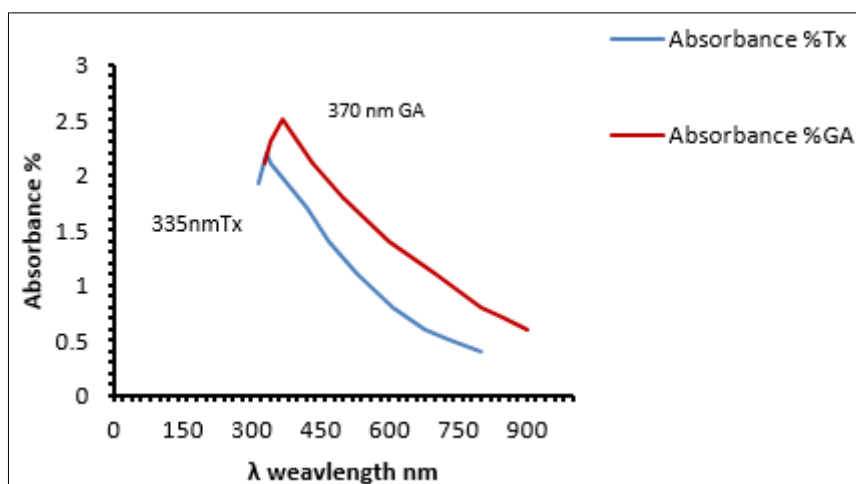


Figure 3. UV-VIS spectrum of of ZnO/EG nanofluids with 0.5 vol.% Gum Arabic and Tx-100 just after preparation

After 60 days of storage an another spectrometry test was taken to the ZnO/ethylene glycol nanofluids showing that the wavelength of absorption peaks was shifted at 380nm and 355 nm, respectively. This indicates the higher stability of nanofluids with GA surfactant addition than with Tx-100 for the same concentration, as shown in Figure 4.

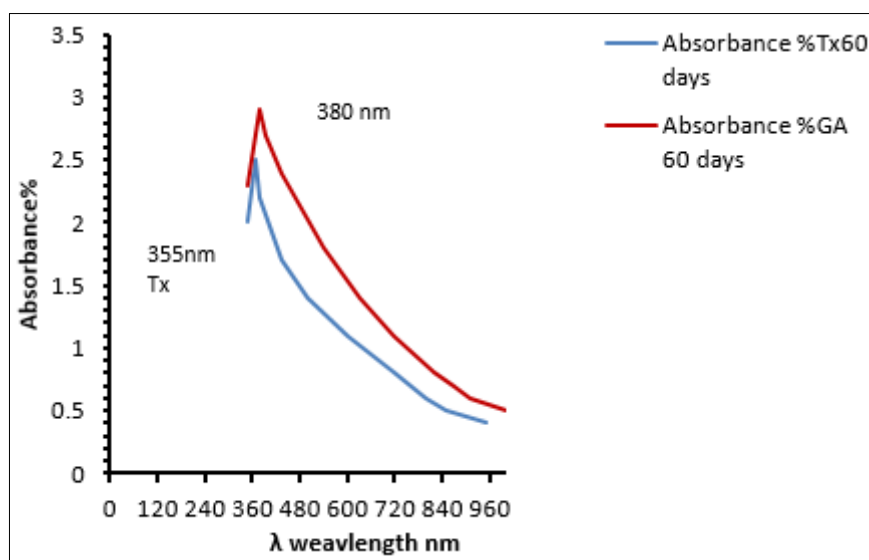


Figure 4. UV-Vis spectrum of ZnO/EG nanofluids with 0.5 vol.% Gum Arabic and Tx-100 after 60 days storage

3.3 Thermal conductivity coefficient

The thermal conductivity represents the most important parameter factor to save thermal energy in any system[19]. We measured thermal conductivity coefficient of simple ZnO/ ethylene glycol mixtures of different concentrations, and then with addition of surfactants Gum Arabic and Tx-100. The results showed that the thermal conductivity coefficient of ZnO/ ethylene glycol simple suspension enhanced when zinc oxide nanoparticles fraction in the mixture increased as shown in Figure 5, this being in agreement with results of other authors [20–22].

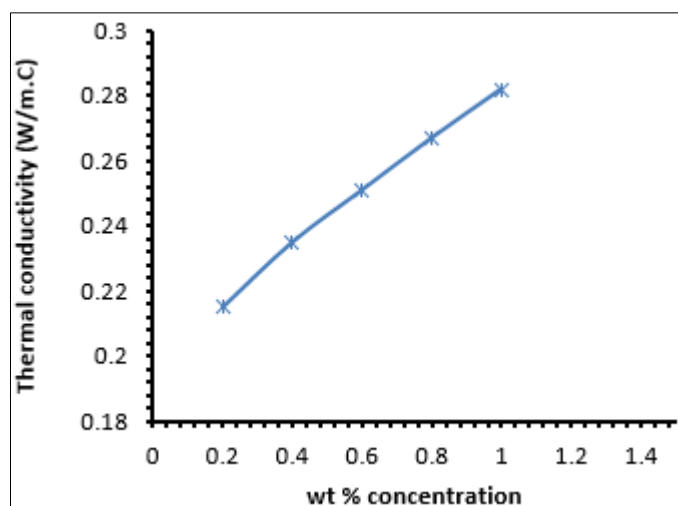


Figure 5. Thermal conductivity coefficient of simple ZnO/EG nanofluids at different ZnO concentrations

Figure 6 shows the values of thermal conductivity coefficient with addition of surfactants Gum Arabic and Tx-100. The results revealed that this parameter of ZnO/EG with Gum Arabic stabilizer has higher values compared to the thermal conductivity of ZnO/EG containing Tx-100 surfactant. This behavior suggests a higher stability of ZnO/EG nanofluids with Gum Arabic. The results also agreed with values obtained by other authors [23–25].

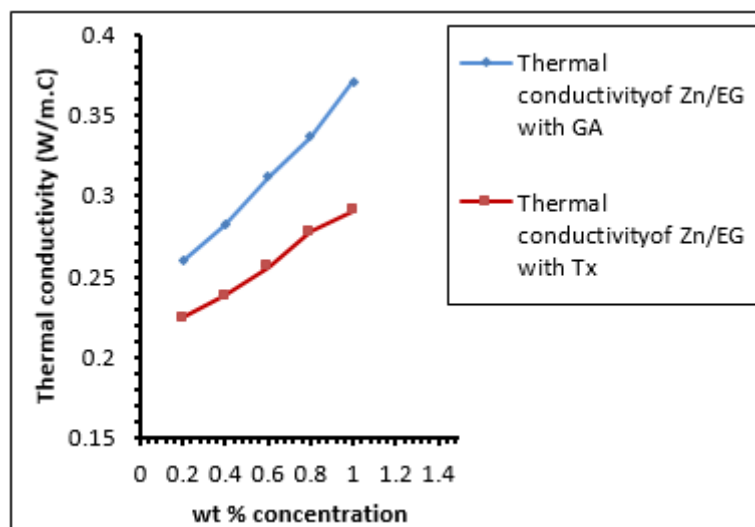


Figure 6. Thermal conductivity coefficient of ZnO/EG nanofluids containing Gum Arabic (GA) and Tx-100 with different stabilizer concentrations

4. Conclusions

Taking into account that the stability of nanofluids with solid particles content is one of the most important factors to ensure the most benefit of their properties, the stability of prepared ZnO/EG nanofluids was measured by two ways, determining the zeta potential and wavelength of absorption peaks in UV-Vis spectra. The results revealed that Gum Arabic stabilizer showed larger stability compared to the Tx-100 in the ZnO/EG nanofluids. The determined values of thermal conductivity coefficient of prepared nanofluids with addition of surfactants indicated that the thermal conductivity may increase up to 35% compared to the ZnO/EG without surfactants.



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