Extended Abstract

Investigating the Effect of Various Factors on the Stability of Nanofluids Containing Metal Oxide Nanoparticles Based on Ethylene Glycol

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Abstract:

In this study, nanofluids containing metal oxide nanoparticles (ZnO, CuO, and $Zn_{0.97}Cu_{0.03}O$) were prepared based on ethylene glycol with 0.1, 0.25, and 0.5 wt.%. The effect of various factors, including the type of ultrasonic device, ultrasonic time, addition of sodium dodecyl sulfate (SDS) as a surfactant, and surface modification of metal oxide nanoparticles using a mixture of oleic acid and oxylene on the stability of the samples was investigated. UV-vis spectroscopy was used to investigate the stability of the nanofluids. The results showed that the functionalization of nanoparticles had the greatest effect on the stability of the samples, as the nanofluids containing functionalized nanoparticles were stable for about 12 days. It was also observed that for synthesizing the samples, probe ultrasonication is more suitable than bath ultrasonication.

Keywords: Metal oxide nanoparticles; Nanofluids; Stability; Oleic acid, Oxylen.

1. INTRODUCTION

Nanofluids are heat transfer fluids with improved physical properties that consist of a base fluid (such as water, ethylene glycol, or oil-based solutions) with nanoadditives suspended therein [1-2]. Thermal conductivity is an important property of nanofluids that is influenced by a wide range of related factors. Brownian motion [3], nanolayer formation [4], and nanoparticle aggregation [5, 6] are the factors that contribute to the observed thermal conductivity enhancement of nanofluids. The main problem in the use of nanofluids is their instability, because the agglomeration of nanoadditives in the base fluid leads to sedimentation and instability. Therefore, stability is a key issue that affects the properties of nanofluids. To overcome this problem, various methods have been used, such as adding surfactants, using various ultrasonic devices for better dispersion of nanoadditives, surface modification (surface functionalization) of nanoadditives, and pH control [7-9]. In this study, the effect of various factors, including the type of ultrasonic device, ultrasonic time, addition of sodium

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dodecyl sulfate (SDS) as a surfactant, and surface modification of metal oxide nanoparticles (ZnO, CuO, and $Zn_{0.97}Cu_{0.03}O$) using a mixture of oleic acid and oxylene, on the stability of nanofluids containing metal oxide nanoparticles based on ethylene glycol was investigated.

2. MATERIALS AND METHODS

In our previous study [10], the effect of using doped nanoparticles on the thermal conductivity of ethylene glycol-based nanofluids was investigated. ZnO, CuO and $Zn_{1-x}Cu_xO$ nanoparticles were synthesized by the sol-gel auto-combustion method using glycine as fuel with different molar ratios of glycine/metal ions. According to the XRD spectroscopy results, ZnO, CuO, and $Zn_{0.97}Cu_{0.03}O$ nanoparticles were used as additives to prepare ethylene glycol (EG)-based nanofluids with different weight percentages (0.1, 0.25, and 0.5). The thermal conductivity of the samples was measured using a KD2-Pro device and the highest increase in thermal conductivity (about 12.5%) was observed for the nanofluid containing nanoparticles doped with $Zn_{0.97}Cu_{0.03}O$ in the concentration of 0.5% wt. In this study, the effect of various factors on the stability of the prepared nanofluids was investigated by UV-vis spectrometry. For this purpose, after the preparation of each sample, a portion of it was placed in a covered container and kept stationary at room temperature. Using a sampler, a certain volume was removed from the surface of sample at different time intervals and its UV-vis spectrum was recorded. This process was repeated for all samples until the stability of the sample was disturbed.

3. RESULTS AND DISCUSSION

The effect of various factors on the stability of the samples was investigated. The results showed that ultrasonic time and addition of SDS did not have a significant effect on improving the stability of the samples, while the type of ultrasonic device and surface functionalization of nanoparticles were effective in improving the stability of the samples. It was observed that probe ultrasonication is more suitable than bath ultrasonication for sample preparation. For functionalization of the nanoparticles, a mixture of oleic acid and oxylene was used with different ratios of 3%, 5%, 7%, 9%, 10%, 30%, 40%, and 50%. The results showed that by increasing the ratio of oxylene to oleic acid to 30%, 40% and 50%, an increase in the stability of the nanofluids was observed. The results of UV-vis spectroscopy of nanofluids containing functionalized ZnO nanoparticles with 0.25 wt.% concentration are shown in Figure 1. As can be seen, the ratio of 50% has better stability compared to 30% and 40% and the sample has stability for about 7 days. In addition, ZnO nanoparticles functionalized with a ratio of 50% oxylene to oleic acid were also used to prepare samples with concentrations of 0.1 and 0.5 wt.%. The results of UV-vis spectroscopy of the samples showed that the sample with 0.25 wt.% concentration, was more stable than the other samples.

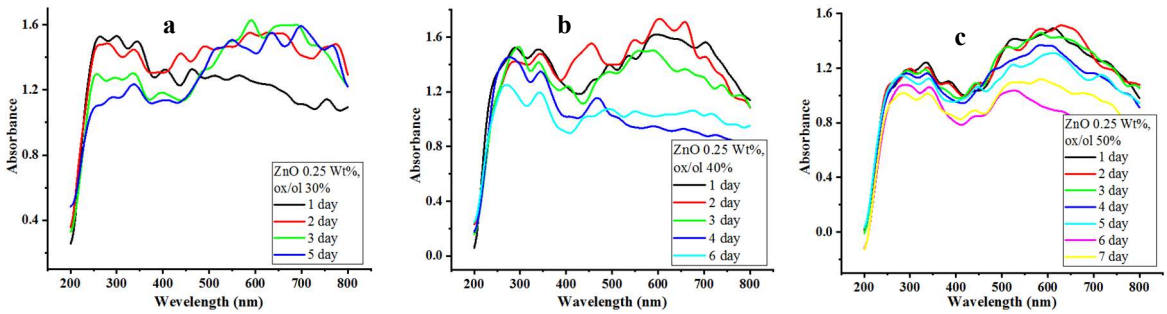


Figure 1. UV-vis spectroscopy of nanofluids with 0.25 wt.% concentration containing functionalized ZnO nanoparticles with oxylene to oleic acid ratios of a) 30%, b) 40%, and c) 50%.

Based on the results obtained for nanofluids containing functionalized ZnO nanoparticles, a similar process was performed for functionalization of CuO nanoparticles using a 50% oxyethylene to oleic acid mixture. The functionalized CuO nanoparticles were used to prepare ethylene glycol-based nanofluids with concentrations of 0.1, 0.25, and 0.5 wt%. The results of UV-vis spectroscopy of the samples showed that the sample with 0.5 wt.% concentration, was more stable than the other samples. The stability was about 4 days after preparation. In order to investigate the effect of functionalization on the stability of ethylene glycol-based nanofluids containing $Zn_{0.97}Cu_{0.03}O$ nanoparticles, a mixture of oxyethylene to oleic acid with a ratio of 50% was used to functionalize the nanoparticles. Then, the functionalized $Zn_{0.97}Cu_{0.03}O$ nanoparticles were used to prepare ethylene glycol-based nanofluids with concentrations of 0.1, 0.25, and 0.5 wt%. The results of UV-vis spectroscopy of the prepared samples are shown in Figure 2. As observed, the sample with 0.1 wt.% concentration, was more stable than the other samples. The stability was about 12 days after preparation. Overall, it was observed that for all concentrations, the stability of nanofluids has improved compared to samples prepared with ZnO and CuO nanoparticles.

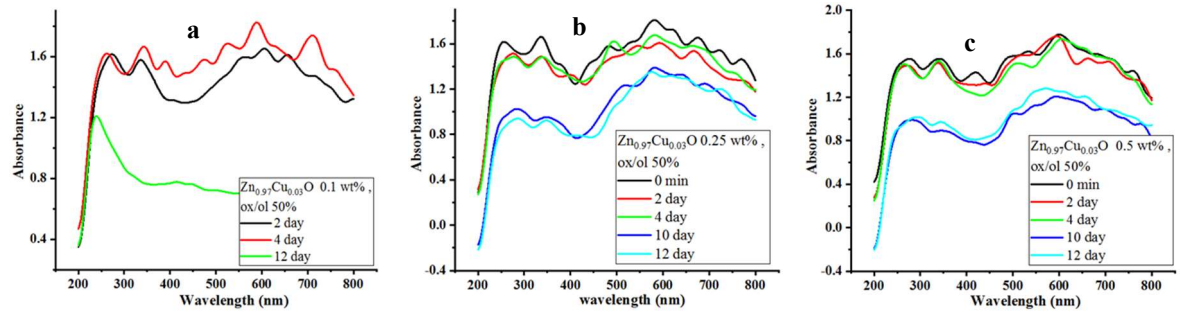


Figure 2. UV-vis spectroscopy of nanofluids containing Zn0.97Cu0.03O nanoparticles functionalized with a ratio of oxylene to oleic acid of 50% with weight percentages of a) 0.1, b) 0.25, and c) 0.5.

4. CONCLUSION

In this study, nanofluids containing metal oxide nanoparticles (ZnO, CuO, and $Zn_{0.97}Cu_{0.03}O$) were prepared based on ethylene glycol with concentrations of 0.1, 0.25, and 0.5 wt.%. The effect of various factors, including the type of ultrasonic device, ultrasonic time, addition of sodium dodecyl sulfate (SDS) as a surfactant, and surface modification of metal oxide nanoparticles using a mixture of oleic acid and oxylene on the stability of the samples was investigated. The results showed that functionalization of nanoparticles had the greatest effect on the stability of the samples, as nanofluids containing functionalized $Zn_{0.97}Cu_{0.03}O$ nanoparticles were stable for about 12 days.

5. ACKNOWLEDGEMENT

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