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Research Paper

Effect of temperature and weight percentage of aluminum oxide nanoparticles on thermophysical properties of nanofluid

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1. ABSTRACT

In this research, the effect of temperature and weight percentage of aluminum oxide nanoparticles on the thermophysical properties of nanofluid was studied. Aluminum oxide nanoparticles were synthesized and the methods of using surfactant, ultrasonic vibration and changing acidity were used to disperse the nanoparticles in base fluid. The effect of 0.1 - 0.5 weight percent of nanoparticles at temperatures of 25, 45 and 65°C on the thermophysical properties of nanofluid was investigated. Maximum stability of nanofluid based on water and ethylene glycol with 25 and 75% by volume, respectively was achieved in a one-to-one weight ratio of sodium dodecyl sulfate to nanoparticles. With increasing temperature and weight percentage of nanoparticles, the thermal conductivity increased nonlinearly. Density and viscosity increased with increasing weight percentage and decreasing temperature. The results showed that the maximum increase in thermal conductivity was 76.2% at a temperature of 25°C and 0.5% by weight of nanoparticles.

Keywords: Nanofluid, Aluminum Oxide, Viscosity, Weight Percentage, Thermal Conductivity.

2. INTRODUCTION

One of the most important concerns of factories and industries that face heat transfer is cooling systems. Optimizing heat transfer systems is usually done by increasing their surface, which increases the volume and size of the devices. To overcome this problem, new and effective coolers are needed. By preparing nanofluids, a new fluid is obtained that has completely different properties than the original fluid and has good heat transfer capabilities. So far, several types of nanofluids have been studied [1, 2]. The stability and uniformity of the suspension, the non-change of the chemical nature of the nanofluid, and the prevention of excessive agglomeration of the particles are very important for the preparation of the nanofluid. To achieve this goal, different methods can be used, such as changing the pH of the suspension solution, using surfactants and anti-coagulant particles, or using ultrasonics.

This article focuses on the synthesis and properties of aluminum oxide nanoparticles and the preparation of its nanofluids. The base fluid is distilled water (25% by volume) and ethylene glycol (75% by volume). Sodium dodecyl sulfate (SDS) was used as a surfactant and the effect of changing pH and ultrasonic time on the stability of nanofluid was investigated. Also, the effect of nanoparticle concentration and temperature on the thermophysical properties of aluminum oxide nanofluid, including density, viscosity, specific heat capacity, and thermal conductivity were investigated.

3. MATERIALS AND METHODS

3.1. Preparation of aluminum oxide nanoparticles and nanofluid

The steps of making and preparing aluminum oxide nanoparticles include the preparation of electrolyte solution, sonication and masking of electrodes and preparation of the oxidation cell in a thermostatic bath. The electrodes are made of aluminum and the electrolyte for preparing Al_2O_3 nanoparticles was prepared by electrocrystallization of metallic aluminum by dissolving tetramethylammonium chloride salt in water. In

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order to prepare Al_2O_3 nanoparticles, the heating water bath was set at a temperature of 10 to 60 degrees Celsius, and after the set was completely at the same temperature, the necessary voltage from 5 to 25 volts was applied to the system by the DC power supply. With the start of the reaction, the color of the electrolyte solution changed from colorless to milky and finally to white. After 30 minutes, the electric current was cut off and the sediment produced by the centrifuge was separated from the solution, and in order to remove the amine attached to the surface of the collected sediment particles, it was washed several times and then left to dry at room temperature. The obtained powder was heated for 2 hours at a temperature of 600 °C in the oven [3]. A two-step method has been used to prepare nanofluids. In order to prepare nanofluid, SDS was dissolved in distilled water (25% by weight) and ethylene glycol (75% by weight) as surfactant, and nanoparticles were added to the solution. The resulting mixture was ultrasonicated for 390 min. The best stabilization of stability was observed at pH=7.5. In this study, 4 fluid samples including 3 aluminum oxide nanofluid samples with 0.1, 0.3 and 0.5 weight percent and a base fluid were prepared.

4. RESULTS AND DISCUSSION

4.1. Characterization of aluminum oxide nanoparticles

FTIR, XRD, SEM and TEM spectra of aluminum oxide nanoparticles are shown in Fig. 1. The peaks related to the OH vibrations of water, the vibrations of C-N bonds in the tetramethylammonium chloride molecule and the Al-O bond in the structure of aluminum oxide are known in FTIR. According to the Debye-Scherer relation, the broadening of the peaks indicates the very small size of the nanocrystals. The particles have a quasi-spherical shape and the average size of the particles was estimated to be around 20 nm.

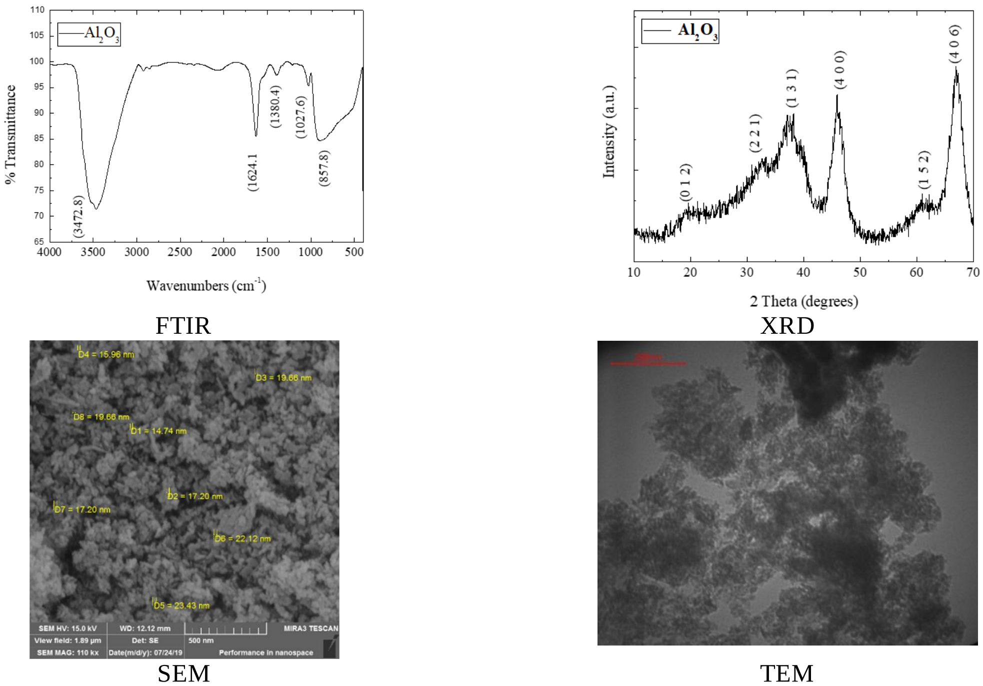


Figure 1. FTIR, XRD, SEM and TEM spectra of aluminum oxide nanoparticles

4.2. Viscosity and density of aluminum oxide nanofluid versus temperature and weight percentage

Figs. 2 and 3 show the viscosity and density of aluminum oxide nanofluid as well as the base fluid containing distilled water (25%) and ethylene glycol (75%) according to changes in temperature and weight percentage of nanoparticles. Viscosity and density of all nanofluid samples decrease with increasing temperature and increase with increasing weight percentage of particles.

4.3. Investigation of specific heat capacity and thermal conductivity versus temperature and weight percentage

Changes in specific heat capacity and thermal conductivity of base fluid and aluminum oxide nanofluid with temperature and weight percentage of nanoparticles are shown in Fig. 4. The specific heat capacity has increased with increasing temperature for all samples. Also, the heat capacity of nanofluids containing 0.1% of aluminum oxide is slightly increased compared to the base fluid, but this parameter is reduced by dispersing

0.3% of nanoparticles and increases again by increasing the weight percentage to 0.5%. In addition, by adding nanoparticles, the thermal conductivity of nanofluid increases for all prepared samples.

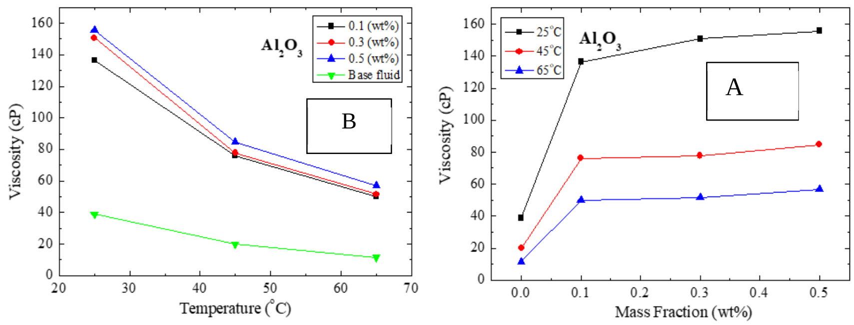


Figure 2. Viscosity of aluminum oxide nanofluid A) versus weight percentage B) versus temperature

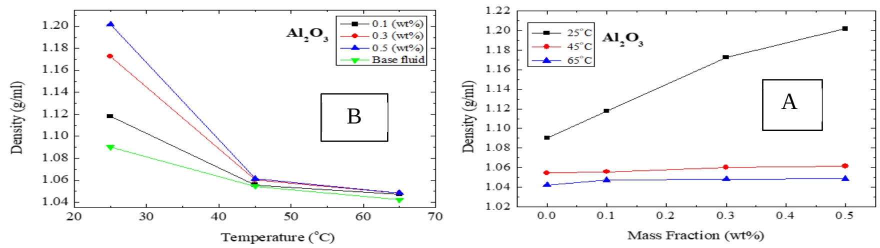
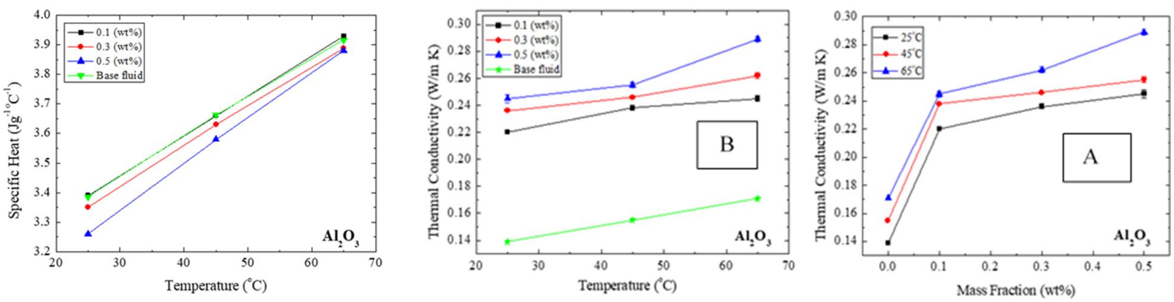


Figure 3. Density of aluminum oxide nanofluid A) versus weight percentage B) versus temperature



(1) (2)

Figure 4. (1) Specific heat capacity of aluminum oxide nanofluid versus temperature, (2) thermal conductivity of aluminum oxide nanofluid versus (A) weight percentage and (B) temperature

5. CONCLUSION

Aluminum oxide nanoparticles and its nanofluid were prepared. The structure of nanoparticles was confirmed by XRD. The average size of aluminum oxide particles was 10 nm. The stability of nanofluids was greatly improved by using sodium dodecyl sulfate as a surfactant and setting pH = 7.5. Samples of aluminum oxide nanofluids with weight percentage of 0.1, 0.3 and 0.5 were prepared and their thermophysical properties were investigated. The density and viscosity of nanofluids decreased with increasing temperature and the specific heat capacity increased with increasing temperature. Maximum increase in thermal conductivity was 76.2% at 25°C and with 0.5% weight of nanoparticles.

6. REFERENCES

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