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Effect of nano particles on electrical conductivity and viscosity subject to a cyclic temperature pattern

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ABSTRACT

The paper investigates the effect of thermal loading on viscosity and electrical conductivity of weakly dosed nanofluids. Two types of thermal loadings are examined: (a) a continuous increasing loading from sub-ambient 5°C to 40°C, (b) a heating (5°C $\rightarrow$ 45°C) followed by cooling (45°C$\rightarrow$ 5°C) loading. Results show that electrical conductivity is weakly dependent on thermal loading and is strongly dependent on nano-particle type. Viscosity shows a strong relationship with thermal loading but is weakly nano-particle dependent. Both electrical conductivity and viscosity show weak hysteresis during the cyclic thermal loading for low dosages. This finding is in contrast for a strong hysteresis pattern reported by Nguyen et al.[1] for highly dosed nanofluids.

KEYWORDS

Nanofluids;
Viscosity;
Electrical conductivity;
Hysteresis.

INTRODUCTION

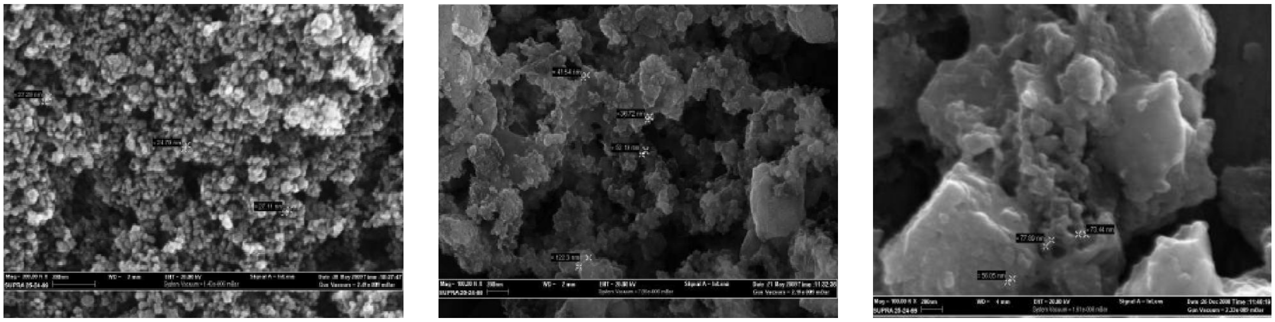
The effect of nano-particles on the electrical conductivity and viscosity is one of the most important technical challenges being faced by many diverse industries including manufacturing, transportation, solid state lighting etc. The basic understandings of nanofluids and nanoparticles are not fully clear. In the recent years, the characteristics and applications of nanosized powders have been studied extensively due to the development of their preparation and processing techniques and special features such as larger surface area[1]. The nano-phase powders with relatively larger surface area improve the heat transfer capabilities remarkably compared with the conventional micrometer-sized powders. The potential uses of nano-particles are in micro channel cooling, miniaturization of system, savings in energy, reduced pumping power etc. The present research work is mainly focused on the preparation, SEM characterization and measurements of viscus and electrical properties of some nanofluids such as TiO_2, SiO_2 and ZnO.

EXPERIMENTAL

Sample preparation

Initially, a sample (TiO_2, SiO_2, and ZnO) is weighted. To prepare a solution of 0.1 wt%, 0.1 gm of sample is weighted. For preparation of 0.1 wt% solution, 100ml DM water is taken in a beaker. After that the measured sample is mixed with the DM water. The beaker is then kept in Ultrasonication bath and the solution is ultrasonicated for 20 mins.

Thus nanofluid is prepared. After that this nanofluid is kept at -9°C for approximately 20 mins in the freezer.



(a) (b) (c)

Figure 1 : (a) SEM picture of TiO_2, (b) SEM picture of SiO_2, (c) SEM picture of ZnO

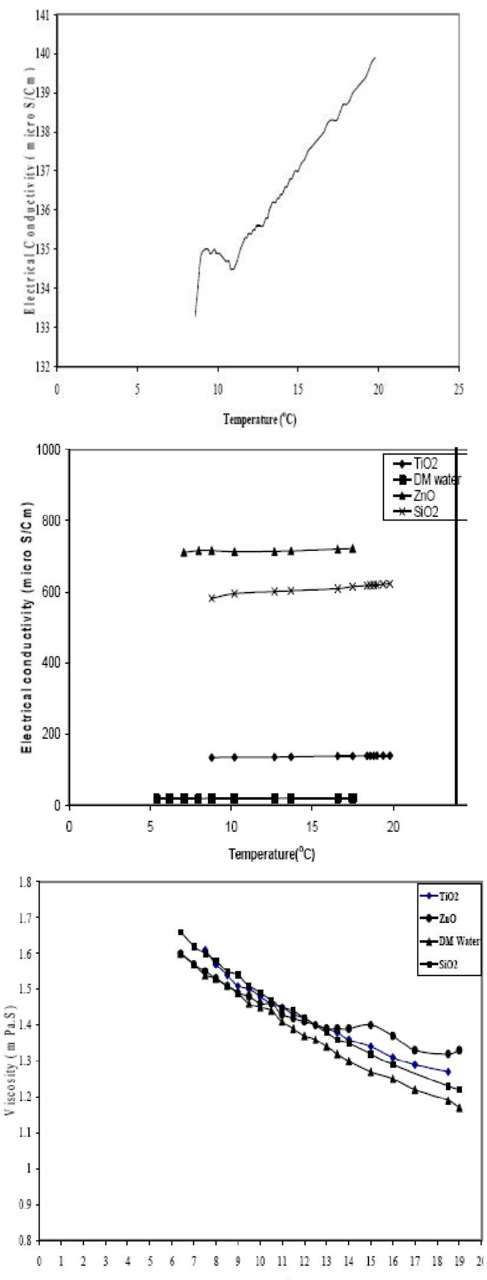


Figure 2 : Results for heating in open air naturally (effect on viscosity)

SEM characterization

(i) The average particle sizes for TiO_2, SiO_2 and ZnO are found to be approximately 24 nm to 28nm, 38nm to 122nm and 58 nm to 77nm.

(ii) The bigger particles shown in figure (a-c) are because of the agglomeration of TiO_2, SiO_2, ZnO nanopowder.

Effect of temperature on electrical conductivity

The effect of temperature on electrical conductivity of TiO_2 is shown in figure 8(a). It is observed from the figure, temperature from 8°C to 20°C, i.e. at sub ambient temperature range. The variation in electrical conductivity with temperature of TiO_2 is found to be 2%. Similar experiments are performed with DM water and ZnO, SiO_2 nanofluids. It is observed from the figure that the electrical conductivity of TiO_2 gradually increases with increase in temperature from 8°C to 20°C, i.e. at sub ambient temperature range. The variation in electrical conductivity with temperature of TiO_2 is found to be 2%. Similar experiments are performed with DM water and ZnO, SiO_2 nanofluids. It is observed from figure 8(b) that the electrical conductivity of different nanofluids and DM water increases with temperature at sub ambient temperature range but the variation is almost same (2%-5%) for all. Hence, it can be concluded that the electrical conductivity of nano-fluid is not a strong function of temperature, but depends on the type of nano-particle at sub ambient temperature range and it differs for different nano particles.

Effect of temperature on viscosity

The temperature variation of viscosity at sub ambient temperature for TiO_2 nanofluid follows the same pattern as it is observed for Al_2O_3 nanofluid. The viscosity gradually decreases with increasing temperature. The viscosity of DM water and SiO_2, ZnO nano fluids decreases with increase in temperature in the sub-ambient temperature range. Figure 8(c) shows the variation of viscosity with increasing temperature when the temperature range is at sub ambient temperature (the variation is 35% to 48%). This observation matches with that of the experiment done by Nguyen et al. figure 8(d) consists of four graphs for same condition for different nano fluids and DM water. It can be concluded that the viscosity is not firmly dependent on the types of nano-particles but is a function of temperature.

CONCLUSION

1 The electrical conductivity of nanofluids is weakly dependent on temperature to the extent of 2 % – 5 %.

2 There is no hysteresis of electrical conductivity of nanofluids for the range of volume fraction tested during cyclic temperature pattern.

3 The electrical conductivity of nanofluids varies as the function of the types of nano-particles.

4 The viscosity of nanofluids decreases with the increase in temperature in the sub-ambient range of temperature (variation is 35-48%).

5 Viscosity does not vary as the function of the types of nano-particles.

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