Investigation of viscosity of SiC nanofluids for nuclear applications

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1. Introduction

Nanofluids are a new class of nanotechnology-based transfer fluids engineered by dispersing and stably suspending nanoparticles in traditional heat transfer fluids such as water, ethylene glycol, and engine oil [1]. While the prediction and measurement of the effective thermal conductivity of nanofluids have received much attention in recent years, very few studies have been performed on effective viscosity, which influences the flow and heat transfer characteristics [2]. For example, regarding SiC/DIW nanofluids, H. Xie [3] reported about the thermal conductivity of SiC/DIW nanofluids. In particular, in order to systemize the design of so-called nanofluid-engineered nuclear safety systems [4] such as Emergency Core Cooling System (ECCS) and External Reactor Vessel Cooling System (ERVCS), the viscosity data of nanofluids are essential. For example, it affects an injection time or speed relating to fluidic behaviors such as pressure loss/fluid resistance. Thus, in this study the viscosity of SiC/DIW nanofluids are measured.

2. Test and Results

2.1 Preparation of the Test

SiC/DIW nanofluids are prepared by dispersing SiC nanoparticles into distilled water as a base fluid. SiC nanopaticles in this test were manufactured by Sigma Aldrich Corporation(true density = 3,160 kg/m^3).

Because the properties of the nanofluids depend on the shape and size of nanoparticles, the image of Fig. 1 was taken by transmission electron microscopy(TEM), the images of Fig. 2(a) and Fig. 2(b) were taken by Scanning Electron Microscope (SEM).

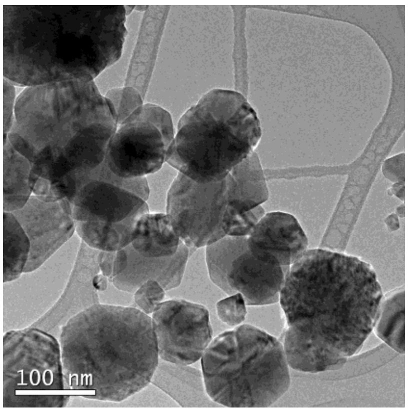
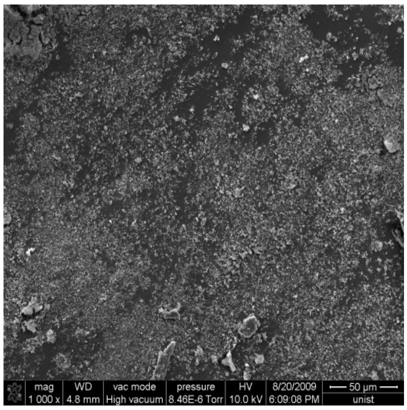
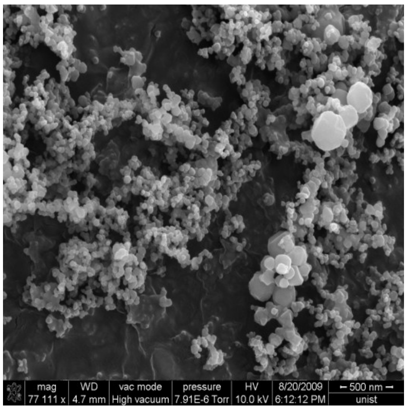


Fig. 1. TEM image of SiC nanopaticles

As shown in the images of Fig. 1 and Fig. 2(b), SiC nanoparticles have a spherical shape. The size has a under 100 nm.



(a)

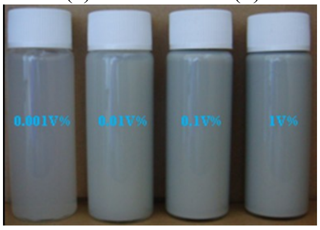


(b)

Fig. 2. SEM image of SiC nanopaticles: (a) in 50 micro-meter , (b) in 500 nano-meter

The process of preparation of SiC/DIW nanofluids is as follow: 1) weigh the mass of SiC nanoparticles by a digital electronic balance; 2) put SiC nanoparticles into the weighed distilled water and get the SiC/DIW mixture as shown in Fig. 3 (a); 3) sonicate the mixture continuously for 12 hours with PowerSonic 420(made by Hwashin Technology Company, Republic of Korea) to obtain uniform dispersion of nanoparticles in distilled water as shown in Fig. 3 (b). Through this preparation, the temperature of nanofluids increases from 24℃ to 55℃. As shown in Fig. 3, the prepared nanofluids with the sonication processing have the more uniform and stable dispersion than the mixture without the sonication processing.

(a) (b)



(c)

Fig. 3. Photos of prepared SiC/DIW nanofluids. (a) before sonication processing in 0.1V%. (b) after sonication processing for 12 hours in 0.1V%. (c) after sonication processing for 12 hours in 0.001V%, 0.01V%, 0.1V% and 1V%

2.2 Viscosity Evaluation

The viscosity of SiC/DIW nanofluids at different volume fraction is measured with SV-10(Vibro Viscometer, made by A&D Company, Japan). The viscosity of distilled water is calibrated and measured as shown in Fig. 4 and the maximum experimental uncertainty for viscosity was 8.3%. The values obtained from tests are compared with Eq. (1) which is the correlation for water dynamic viscosity [5].

$$\mu = e^{(1.12646-0.039638\cdot T)/(1-0.00729769\cdot T)}/10000 \qquad (1)$$

where μ is the viscosity of DIW (mPa·s), T is the absolute temperature(K).

Then the viscosity of SiC/DIW nanofluids was measured.

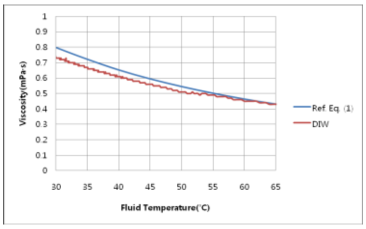
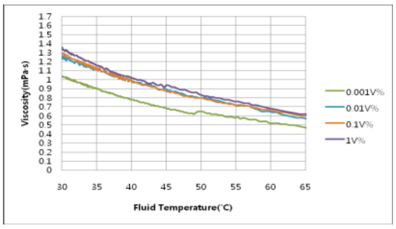


Fig. 4. Viscosity-Fluid Temperature curve of DIW and calibration

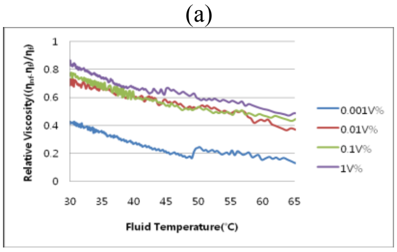
2.3 Test Results

The viscosity of SiC/DIW nanofluids had not been reported up to now. It can be seen that the measured viscosity data for SiC/DIW nanofluids in Fig. 5 (a). Namely, the viscosity of SiC/DIW nanofluids increases with increase of volume fraction. But, as volume fraction increases, the viscosity difference of prior volume fraction is more smaller. The increase of viscosity with increase of volume fraction may decrease the potential benefits of nanofluids.

As shown in Fig 5 (b), it can be seen that relative viscosity data for SiC/DIW nanofluids with the volume fraction and temperature. For example, in the 1V% of SiC/DIW nanofluid, the increase of relative viscosity with the DIW ranges from 45% to 87%.



(a)



(b)

Fig. 5. (a) Viscosity-Fluid Temperature curve of SiC/DIW nanofluids. (b) Relative Viscosity-Fluid Temperature curve of SiC/DIW nanofluids with the DIW.

3. Conclusions

In order to investigate the viscosity of SiC/DIW nanofluids, the viscosity tests were performed. For example, our measured maximum relative viscosity data for the 1V% of SiC/DIW nanofluids with DIW was 87%. The increase of viscosity with increase of volume fraction may diminish the potential benefits of nanofluids. Therfore, it is essential to make an experiment more comprehensively on the viscosity of nanofluids.

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