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Thermophysical properties of nanofluids MWCNT (multi-walled carbon nanotubes) in water for emergency coolant from nuclear reactors

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ABSTRACT

To evaluate the synthesis and characterization of MWCNT (Multi-walled Carbon Nanotubes) with different degrees of functionalization in distilled water. The thermophysical properties (thermal conductivity and viscosity) of these nanofluids were measured at a temperature range (20-60°C) and concentrations (0.005-0.05%) by volume. Increases in thermal conductivity and viscosity were found 9.3% and 4.7%, respectively, at a volumetric concentration of 0.01% at a temperature of 30°C. The study of new fluids that improve the rate of removal of heat is fundamental to obtain greater efficiency of energy systems. Among the several factors that compromise the efficiency of the energy systems, we can highlight the thermophysical limitations of the conventional fluids, inhibiting in a very significant way some industrial applications. In this work we intend to improve the heat transfer characteristics of fluids commonly used by the addition of nanoparticles, made up of carbon nanotubes, in water which is the most used fluid for the cooling of nuclear reactors in operation today. It is intended to improve the heat transfer characteristics of fluids commonly used by the addition of nanoparticles, made of carbon nanotubes, through the addition of nanoparticles, made up of carbon nanotubes, in water which is the most used fluid for refrigeration of nuclear reactors currently in operation. In order to assess its benefits for the applicability and nuclear systems, ie primary coolant, safety systems, major accident mitigation strategies.

Keywords: Nuclear reactor, coolant, nanofluids, thermal conductivity, viscosity.

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1. INTRODUCTION

A nanofluids are composed of colloidal dispersions with a traditional refrigerant as a base on which the nanoparticles are suspended. They became part of the scientific scenario in 1995, when researcher Stephen US Choi and his collaborators aimed to improve the heat transfer process for optical elements of high-flow X-ray apparatus in Argonne National Laboratory and reported significant improvements in heat transfer performance [1].

In one of the pioneering works [2] dispersed ultrafine particles of Al_2O_3, SiO_2 and TiO_2 in a base fluid using electrostatic repulsion obtaining an increase in the thermal conductivity proportional to the concentration. Ultrafine particles or nanoparticles, with sizes between 1 and 100 nanometers (nm) (1 nm = 10-9 m) have distinct physical and chemical properties when compared to the properties of particles with the same materials.

In view of energy security and environmental concern, the performance of the refrigeration system needs to be improved, which can be done by modifying the systems or properties of the primary and secondary working fluids. Recently, nanofluids or hybrid nanofluids have gained interest in many engineering fields because of their excellent thermophysical properties, which can be easily used in refrigeration and air conditioning systems for many performance enhancing functions.

Due to energy security and environmental concern, the performance of coolant systems needs to be improved, which can be done by modifying the systems or properties of primary and secondary working fluids. Recently, nanofluids have gained interest in many engineering fields because of their excellent thermophysical properties, which can easily be used in refrigeration and air conditioning systems for many performance enhancing functions [3].

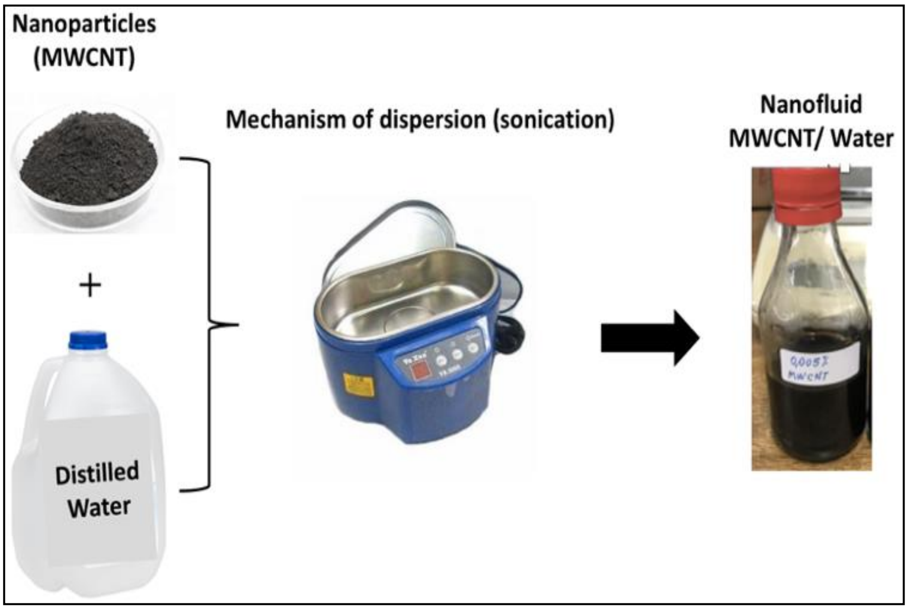
With the aim of measuring the conductivity of various types of nanofluids, carried out a series of measurements in several research centers around the world. In this study it was verified that the results for thermal conductivity found by the various researchers were within a range of deviation of ± 10% showing the importance of the characterization of the thermal conductivity and showing that its increase increases with the increase of the nanoparticle concentration and the ratio of aspect [4].

This work aims to evaluate the synthesis and characterization of nanofluids of carbon nanotubes of multiple walls (MWCNT) functionalized with -OH in distilled water. For this, the thermophysical properties of these nanofluids were measured: thermal conductivity and viscosity under various temperatures (20-50 °C) and concentration range of 0.005 to 0.01% by volume.

2. MATERIALS AND METHODS

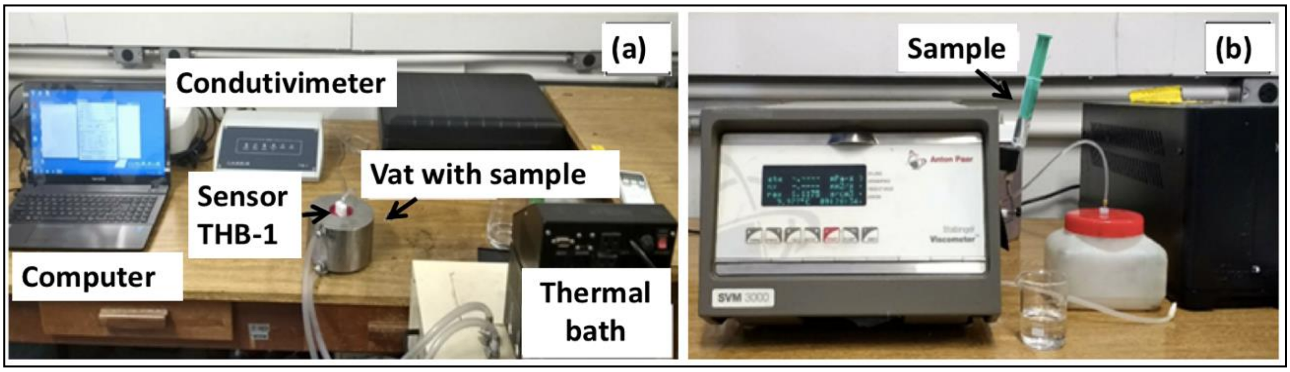
The preparation of the nanofluids is a rather important step to better the thermal conductivity. There are two most commonly used methods of nanofluid production, the one-step method and the two-step method. The two-step method was used for the development of nanofluids. The synthesis of nanofluids was performed by dispersing MWCNT nanoparticles in distilled water and by homogenization by sonication, as shown in Figure 1:

Figure 1: *Representative scheme of the two-step method for the synthesis of nanofluids.*



The nanofluids produced were characterized in order to obtain their thermophysical properties: viscosity and thermal conductivity. For these measurements, an Anton Paar SVM 3000 viscometer and a Linseis brand THB-1 conductivity meter were used. In Figure 2 it is possible to observe in (a) the photograph of the conductivity measuring apparatus and in (b) a photograph of the viscometer used.

Figure 2: *Representative scheme of the Two Step method for the synthesis of nanofluids. (a) image of the experimental apparatus for measuring thermal conductivity, (b) image of the viscometer SVM 3000*.



3. RESULTS AND DISCUSSION

According to the results, the addition of MWCNT nanoparticles in distilled water increased both the conductivity and the viscosity of the distilled water. Since the increase in thermal conductivity was higher than that of viscosity in most of the temperature ranges. Increases in viscosity and conductivity of 9.3% and 4.7%, respectively, were found for volumetric concentration of 0.01% at the temperature of 30 °C. For higher temperatures the increase in viscosity tends to decrease and that of the thermal conductivity increases. For high temperatures there is significant increase in thermal conductivity with low viscosity impairment.

Figure 3: *Thermal conductivity for MWCNT nanofluids in water.*

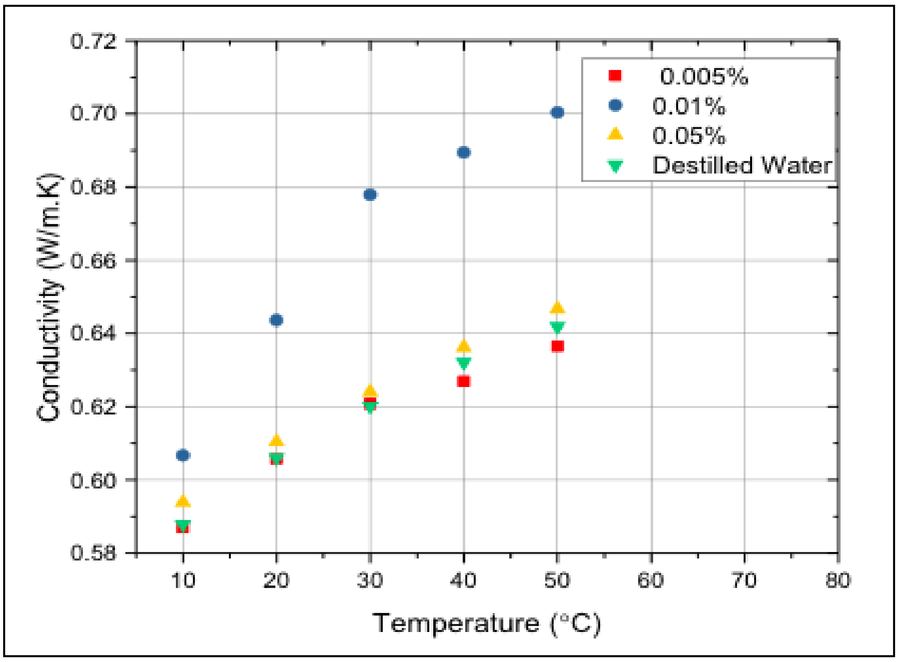
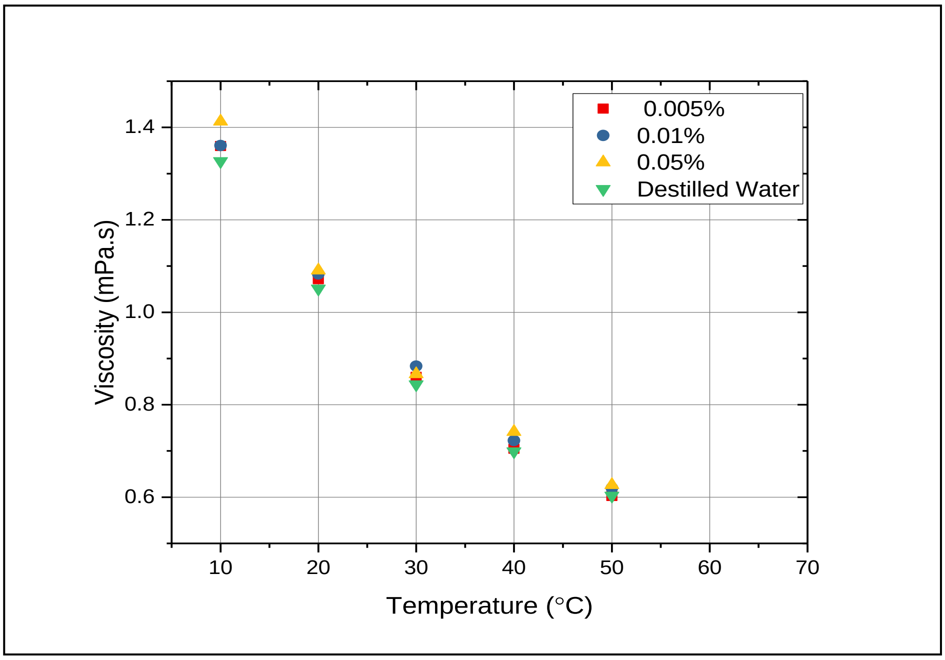


Figure 4: *Viscosity for MWCNT nanofluids in water.*



4. CONCLUSIONS

The synthesis of nanofluids is one of the most important and fundamental steps before the application of these fluids in thermal exchanges. In addition, the characterization of the thermophysical properties of the nanofluids is essential to ensure good thermal performance, thus enabling the use of nanofluids on a large scale. With the results obtained in the evaluation of thermophysical characteristics: thermal conductivity and viscosity, it was possible to conclude that the addition of MWCNT nanoparticles in water guaranteed the increase in thermal conductivity without significantly increasing viscosity. Thus, the synthesis and characterization of these nanofluids presented good experimental results for application in thermal exchanges of these nanofluids.

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