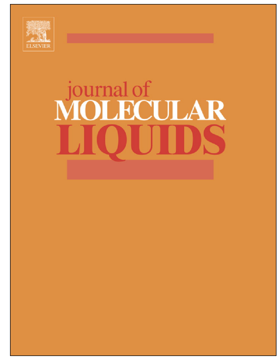
Accepted Manuscript



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PII: S0167-7322(18)31194-2
DOI: doi:10.1016/j.molliq.2018.04.012
Reference: MOLLIQ 8915

To appear in: *Journal of Molecular Liquids*

Received date: 7 March 2018
Revised date: 29 March 2018
Accepted date: 3 April 2018

Isobaric heat capacity and density of ethylene glycol based nanofluids containing various nitride nanoparticle types: an experimental study

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Abstract

This work presents experimental results on the isobaric heat capacity of ethylene glycol (EG) based nanofluids containing three types of nitride nanoparticles: aluminum nitride (AlN), silicon nitride (Si_3N_4) and titanium nitride (TiN). The densities of the nanofluids were also investigated in this study. Each type of material was used in two different sizes of nanoparticles and with various values of specific surface area. Temperature-modulated differential scanning calorimetry and vibrating tube techniques were used, and measurements were performed at three different temperatures: 288.15 K, 298.15 K and 308.15 K. The obtained experimental results were compared with the predictions of theoretical models, and absolute average deviations were calculated. It was demonstrated that the fraction of nanoparticles strongly affects isobaric heat capacity and density, whilst the size of the particles does not significantly impact these properties.

Keywords: nanofluid, ethylene glycol, nitride, density, isobaric heat capacity

1. Introduction

Energy consumption has strongly risen during the last century due to the global world population increase, the large development of industry, the major use of energy in daily human activities, and a growing utilization of transport. According to the REN21 Renewables 2017 Global Status Report [1], among the total world energy consumption in 2015, approximately 78.4% was provided by fossil fuels, 2.3% by nuclear power and still only 19.3% by renewable energies. However, the awareness of worldwide population in terms of climate change associated with the emission of greenhouse gases has increased. Thus, several countries have signed different protocols with the aim of reducing emissions by means of material prohibitions, fee payments for the most polluting sectors, and obligations of energy efficiency enhancements. One of the most well-known was the Kyoto Protocol, initially signed on 11th December of 1997 by the European Union and another 37 countries [2]. Its initial target was to reduce by 5.2% the emissions of a group of greenhouse gases between 2008 and 2012 with respect to the 90s [2, 3]. The Paris Agreement, signed 12th December of 2015 by 195 countries, will replace Kyoto in 2020 and continue trying to mitigate climate change by maintaining the average world temperature increase this century under 2 K [4]. Another example of awareness is that in 2016, for the fifth consecutive year, the investment in the capacity of new renewable power was approximately double that in the capacity of fossil fuel generation [1]. Most of the consumed energy in the world is produced as heat [5], so a lot of efforts have been made in improving the thermal performance of heat transfer processes and facilities, thus minimizing the consumed energy. Initially, the optimization of heat exchangers by modifying the type, material, geometry, exchange surface or insulation, amongst other parameters, was the focus of attention. In the last decades, efforts were partially centered on the enhancement of the thermal properties of working fluids.

Nanofluids are dispersions of solid nanoparticles in a conventional working fluid which is expected to enhance or change its physical properties. Initially, they were conceived as thermal conductivity enhanced-fluids because solids usually possess higher values than liquids, and thermal conductivity is one of the most in-

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