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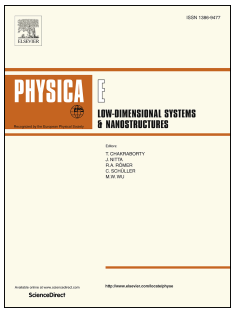

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Ethylene glycol based silicon nitride nanofluids: an experimental study on their thermophysical, electrical and optical properties

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Abstract

This paper presents the results of an experimental investigation into the basic physical properties of silicon nitride (Si_3N_4) – ethylene glycol (EG) nanofluids. Samples with various volume fractions of nanoparticles were prepared using a two step method. Basic physical properties such as viscosity, thermal conductivity, electrical conductivity and optical properties were examined. A rheological investigation showed that silicon nitride ethylene glycol nanofluids present non-Newtonian shear thinning behavior. Thermal conductivity indicates a linear dependence on the volume fraction. As well as thermal conductivity increasing with increasing volume fraction, electrical conductivity is also related with the volume fraction of nanoparticles, and this relation is both very strong and nonlinear. The refractive index increases linearly with the volume fraction of nanoparticles in these nanofluids. Finally, it has been found that absorption of examined nanofluids is improved as the volume fraction of nanoparticles increases, especially in the UV region.

Keywords: nanofluid, silicon nitride, viscosity, thermal conductivity, electrical conductivity

1. Introduction

The last twenty years have been a time of intensive research on the properties of nanoparticle suspensions in a base liquid, known as nanofluids. Reports on the applications of nanofluids have been associated with a significant increase in thermal conductivity, first described by Choi and Eastman [1]. Due to this the main focus of reseacrhers in this field has been the study of the thermal conductivity of nanofluids [2, 3, 4, 5, 6, 7, 8]. However, one should also take into account the widely described changes in rheological properties, especially the increase in viscosity [9, 10, 11]. Unfortunately, currently there is no coherent theoretical model describing the thermal conductivity of nanofluids. There are however complex models applicable to well-defined nanofluids. Aybar et al. [12] presented in their recent review paper a dozen theoretical models of thermal conductivity proposed over the last several years. In another review paper by Mishra [13] dozens of theoretical models, this time describing the changes in the viscosity of nanosuspensions, have been presented. Despite this issue many studies on the applications of nanofluids have been presented [14, 15, 16, 17].

The rapid development of renewable energy sources has intensified work on applications of nanofluids in this sector of industry [18, 19, 20], especially in solar collectors or thermal energy storage systems. Intensive research is also being carried out in order to apply nanofluids to improving the efficiency of nuclear reactors [21, 22].

One of the most often used base fluids is ethylene glycol (EG). These types of nanofluids are interesting from the point of view of basic science, but also from the point of view of potential application, as presented in the recent review paper by Murshed and de Castro [23]. There are many works showing the viscosity and thermal conductivity of EG based nanofluids containing oxides [24, 25, 26, 27, 28, 29, 30], carbon structures [31, 32, 33, 34, 35, 36, 37] and their mixtures [38, 39, 40]. Recently, optical properties of EG based nanofluids were intensively investigated in connection with the potential application of these materials in solar collectors and other renewable energy solutions [41, 42, 43].

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