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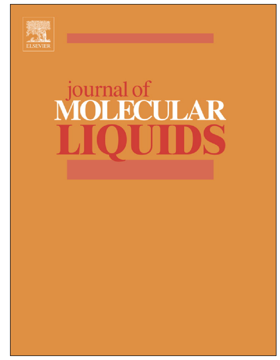

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Particle Size Effect on Thermophysical Properties of Nanofluid and Nanofluid Based Phase Change Materials: A review

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Despite the fact that Nanofluids and nanofluid based phase change materials (PCMs) have been identified as potential candidate for various heat transfer and energy storage applications, they are still facing various challenges such as stability, pressure drop and high pumping power. Nanoparticle size plays a bigger role in hindering nanofluid applications, yet effect of nanoparticles size does not receive the attention it deserves. The inconsistence and contradiction of information gives an impression that the area is not well understood therefore more information need to be made available in the literature. In this paper, the effect of nanoparticle size on thermophysical properties of nanofuid and nanofluid PCMs is reviewed. The work involves discussing the effect of nanoparticle size on thermo-physical properties of nanofluid and nanofluid PCMs through systematic analysis of past experimental and theoretical work. The results show that, thermal conductivity generally increase as nanoparticle size decreases while surface tension increases as nanoparticle size increases. Latent heat of fusion reduces as nanoparticle diameter decreases. Although, nanoparticles increase viscosity, the effect of particle size diameter is not yet clear. More research is therefore needed in this area of nanoparticle size effect on nanofluid and nanofluid PCMs so that optimum size can be established for each application.

Keywords: Nanofluids; Phase change materials; Thermophysical properties; Nanoparticle size.

1. Introduction

With ever increasing population growth, technological advancement and improvement in the quality of life; the energy utilization has been increasing with each passing day [1, 2]. The increase in energy consumption has necessitated the rapid development of advanced thermal materials that have high thermal performance in thermal transport [3–7], thermal energy storage [8-10] and other thermal engineering applications for different purposes to increase efficiency therefore saving energy. One of the novel methods the thermal engineers have invented is the addition of solid particles to a base fluid to make the fluid a better heat transfer fluid [11-13]. Based on this concept, nanofluid was formulated and has been in use in the field of thermal engineering for the last two decades. In most cases, water, ethylene glycol (EG) and thermal oil are used as base fluids for nanofluid applications and organic, inorganic and eutectic PCMs for nanofluid based PCMs which have naturally poor thermal conductivities. Supplementation of nano-scaled metals, metal oxides or carbon based materials to these base fluids brings out the nanofluids for both heat transfer and thermal energy storage [14-16]. The addition of nanomaterials to a liquid alters its thermophysical properties considerably; hence, the thermophysical properties of nanofluids are different from those of base fluid in which the nanoparticles are dispersed. Thermal conductivity [17, 18], viscosity [19-21], latent heat [22] are some of the thermophysical properties of nanofluids that have been extensively studied due to their significant influence on the heat transfer performance of nanofluids and energy storage in nanofluid PCMs. The factors that influence thermophysical properties of nanofluids are size, concentration, aggregate and shape of the nanomaterial used as dispersed solid phase. Properties of base fluid, interaction between nanomaterial and base liquid molecules, surfactant used for formulation, dispersion and pH also affect the behavior of the resultant nanofluid [23].While each of the factors above influence the thermophysical properties of the nanofluid, many researches and review papers have largely given nanoparticle concentration the highest attention[24].Despite the fact that nanofluids have been identified as potential candidate for various applications such as solar water heating, brake fluids, transformer cooling, geothermal application, car radiator, microchannels, nuclear reactor, refrigeration, engine cooling and lubrication, it is still facing various challenges [25]. Some of these challenges are stability, pressure drop, high pumping power due to increased viscosity and its thermal performance in two phase applications such as refrigeration and heat pipe [26]. The high cost for synthesizing nanoparticles, erosion of oxide nanoparticles in the pipes are among other challenges facing nanofluids application [27, 28]. In all these uses nanoparticle size plays a bigger role in hindering nanofluid applications. Large particle diameter clogs the heat exchanger micro-channels thereby preventing flow and causing high pressure drop. Large particles sizes also cause erosion in pipelines when flowing