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Optical properties of metal oxides based nanofluids ☆

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ABSTRACT

The purpose of this research is to experimentally investigate optical behavior of alumina and titania nanofluids. In this study, classical theories such as, Rayleigh, Maxwell–Garnett and Lambert–Beer's approaches are used for analytical analysis. The effect of surfactant on stability of nanofluids has been examined. Experiment is conducted for two volume concentrations of 0.1% to 0.3% *v*/*v* for the optical properties. Both experimental and analytical analyses were used to obtain these properties of nanofluids. Extinction coefficient and refractive index of TiO_2 nanofluids are found higher than Al_2O_3 nanofluids in visible region of light for all concentrations. Results of this work will be very helpful in analyzing direct absorption solar collectors using alumina and titania nanofluids.

1. Introduction

At low particle loadings, nanofluids show significant enhancement in the thermal and optical properties [1]. Long before nanofluid investigation became predominant, the interest of scientists was focused on small particle absorption and scattering of light. Over a 100 years ago most of the recent theory of small particle optical property was established by Gustav Mie. Remarkable overviews were presented on absorption and scattering [2–4]. A proficient theoretic foundation for the absorption and scattering of metallic small-scale particles was presented by Kreibig & Vollmer [5]. Predominantly, in gas–particle mixtures, the radiative properties of small particles were introductory to be functional in other engineered systems by 1970 [6–11]. Nanofluids have been studied from the perspective of governing optical and radiative properties in the preceding numerous years. The optical properties of nanofluids can appreciably change from that of base fluid, and that dependent scattering effects will be of immense significance [12].

Very recently, there has also been a noticeable amount of work on radiative heat transfer of nanofluids. Since this research is focused on solar energy harvesting, this section will be slanted towards absorption of radiative heat from sunlight. As the body of published research expands, it is becoming clear that in this application, as with the other nanofluid applications, the nanofluid mixture must be very carefully chosen. This is especially true for the nanofluid optical properties in a solar collector. Optical properties of the fluid can be remarkably enhanced by adding nanoparticles in suspension to a base liquid [12–14]. The properties are highly dependent upon the particle shape, size, and the optical properties of the base fluid [13]. One of the major advantages of utilizing a system that uses liquid nanoparticle suspensions is the tunability of the size, shape, and volume concentration of the nanoparticles for the operating mode of the system. Small changes in these areas can drastically change scattering and absorption.

Differences in nanoparticle induced optical properties appeared to be promising, resulting in higher sunlight absorption and improved thermal conductivity of the nanofluids compared to that of pure water. Both these effects, along with the possible chemical features of carbon nanohorns, make these nanofluids fascinating for obtaining increased overall efficiency of the sunlight exploiting devices. The optical properties of these nanofluids, including absorption, scattering, and extinction, were theoretically modeled using the Rayleigh approximation. It was observed from the results that multi wall carbon nanotubes (MWCNTs) in nanofluid were more effective for radiation absorption in comparison to Al or CNPs because less energy was scattered away [15]. The full characterization of the optical properties of nanofluids consisting of single-wall carbon nanohorns of different morphologies in aqueous suspensions is carried out using a novel spectrophotometric technique [16]. The transmittance of water can be reduced by <5% within the visible spectrum, when dispersants are applied. ZnO– and AlN–water nanofluids selectively absorb solar radiation, whereas ZrC– and TiN–water nanofluids absorb most of the solar radiation applied to them [17]. The extinction index of four liquids (water, ethylene glycol, propylene glycol, and Therminol VP-1) obtained experimentally [10]. Among these four liquids water showed to be the best absorber of solar energy, absorbing 13% of the energy, which is still low. Efficiency

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